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PŒTSCH'S METHOD OF SINKING MINE SHAFTS.

WE have already, in a preceding number, called attention to Mr. Pœtsch's very original method of sinking shafts through wet soil, and we now return to the subject in order to give a complete description from an interesting article recently published in the *Annales des Mines* by Mr. Lebreton. As we have already stated, the method consists in solidifying in some degree, by freezing, that portion of the moving and watery earth which occupies the position of the projected shaft, so as to permit of excavating therein by hand, without having much pumping to do. To effect this, there is sunk into the ground a series of vertical tubes that traverse the watery stratum and enter the subjacent solid earth to a depth of from 18 to 24 inches. These tubes are arranged in such a way as to constitute a sort of polygon, that envelopes the section of the shaft with sides of from half a yard to a yard in width. The tubes are afterward hermetically closed at the lower extremity, and, as shown in Figs. 1 and 2, there is placed in each of them a smaller tube for introducing the freezing mixture. A continuous circulation is established by directing the liquid into the central tube, and afterward causing it to ascend in the annular space between the two tubes. The liquid becomes heated in its passage, at the expense of the surrounding earth, whose caloric it absorbs, and, after a certain length of time (provided the difference in the temperatures be sufficient), brings about, around each of the tubes, a congelation of a certain zone that progressively extends until it converts the neighboring parts of the earth into a mass of ice. The excavating may then be proceeded with without any fear of influxes of water; but it is necessary of course to take care to prevent the melting of the ice by keeping up a circulation of the cold current during operations. The liquid used for this purpose by Mr. Pœtsch, the inventor of the method, is a solution of chloride of magnesium, or sometimes of chloride of calcium, which is cheaper. The solution contains 19 per cent. of the former salt, and has a density of 1·17, with a specific heat of 0·9. Under such circumstances it solidifies at about —40°. The liquid is set in motion by a peculiar pump, situated at the left of the mouth of the shaft, in a building which is partially shown in Fig. 2, and is distributed by a large external pipe that runs around the mouth and leads it to the central tubes in the direction shown by the arrows. It rises in the large tubes, and, on reaching the surface, is led by a collecting pipe to a refrigerating machine, in order to be deprived of the heat absorbed in traversing the earth. The closing of the tubes is so perfect that the loss of liquid through leakage is insignificant.

The machine used for the production of cold is that of Mr. F. Carré, which, as well known, operates through a utilization of the affinity of water for ammonia. It permits of obtaining particularly low temperatures of from —25° to —30°, that it would be difficult to get with other types of cold-producing machines. We shall not enter into the details of it, but shall merely say that its mean performance is about 20 per cent. The tubes are sunk into the ground through vertical holes bored through the watery stratum, either by means of the sand pump, if the slight consistency of the earth permits of it, or, otherwise, by hand.

In the application of the method shown in Fig. 2, the tubes rise to the surface of the earth; but if the watery stratum be too far from the mouth of the shaft, the latter may be excavated in full section down to the region of the water, and pipes be then inserted that have only sufficient length to traverse the said stratum. It will prove expedient, moreover, to give the upper part of the shaft a wide section surrounding the polygon of tubes, or at least to widen it at the upper level of the latter, in order that they may be carried back beyond the true section of the shaft.

The tubes used by Mr. Pœtsch are cylinders of 0·15 in. sheet iron 8½ inches in diameter. They are sunk into the earth in measure as the excavation proceeds, and are then hermetically closed in order to prevent an outflow of the freezing mixture. This closing, which has to be done from the outside, is generally effected through the arrangement shown in Fig. 1 (No. 1), that is, through the introduction of leaden plugs, which fit into a conical adjustment at the end of the tube, and which are then covered with a layer of clay or gypsum cement. After this, the small central tubes (which have an aperture at A, in order to allow the current to pass) are inserted.

The cooling action of the liquid at every point of its travel in the interior of the tubes depends essentially upon the difference in temperature between such point of the ascending column and that of the earth. This action, moreover, varies throughout the entire length of the tubes, by reason of the continual exchange that occurs, in two contrary directions, between the surrounding earth and the descending column in the central tube acting as a refrigerant. This fact is ascertained by calculation, and we can likewise determine the conditions that are to be observed in order to obtain a minimum of temperature at the bottom of the tubes, and which permit of securing at this point the widest zone of cold. The frozen region then has the appearance of a surface revolving around the axis of the tube, whose meridian is a logarithmic curve that tends to approach the tube at the surface of the earth, according to the outline shown in Fig. 1 (No. 2). Before beginning the excavation, it is necessary to wait in all cases until the zones of ice thus formed around each tube have sufficiently extended to join one another and form a continuous barrier that intercepts all communication with the external water.

In the first application that he made of his method,

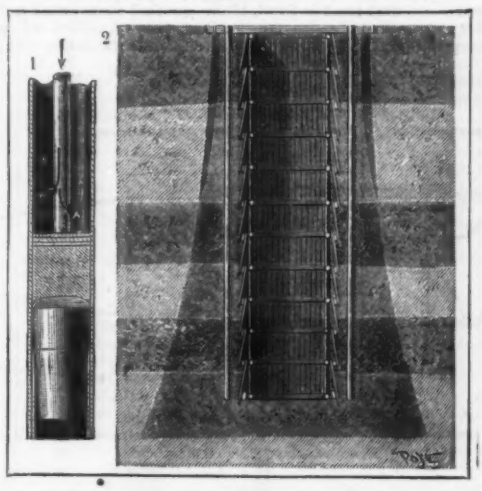


FIG. 1.—THE PŒTSCH METHOD OF SINKING SHAFTS.

Mr. Pœtsch effected a complete congelation of the entire region of earth included within the polygon of tubes, and converted it into a compact mass, wherein excavating was performed without any pumping having to be done; but he now prefers to begin the excavating as soon as he is able to close the ice barrier, without extending the freezing farther. He thus diminishes, in fact, the time that it takes to effect the freezing, and even that which it takes to do the

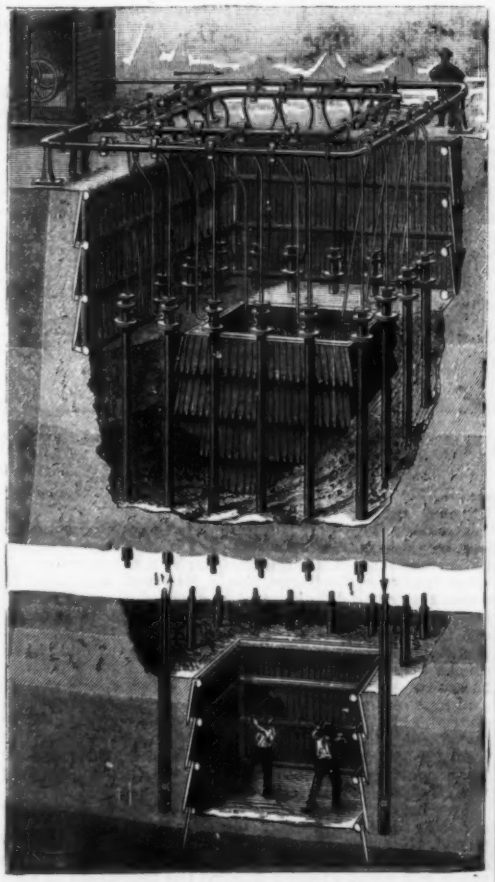


FIG. 2.—SECTION OF A SHAFT SUNK IN WATERY EARTH.

excavating, since the latter operation is executed under much easier and cheaper conditions in earth without consistency than in ice; and it may even be estimated that the progress is thus quadrupled. The pumping, which is confined to the small quantity of water contained within the column of ice, amounts to little, and does not interfere with operations. The excavating, properly so called, presents, as a general thing, no special difficulty resulting from the low temperature; only it is well to put in the timbering pretty rapidly in measure, as the work proceeds, so as to prevent a strain on the wall of ice. The timber used must be very dry, for the freezing of the water contained in the shaft would cause damp wood to fly into splinters.

The Pœtsch method has already been applied in several instances in Germany, and these applications have given results that are generally satisfactory, and have shown how valuable it is for excavating through shifting earth, or earth without consistency. In the most recent application, which was made at the Konigs Wusterhausen mine, near Berlin, the arrangement (Fig. 2) comprised 16 tubes, 9¾ feet in length, 3¼ feet distant from axis to axis, and placed at 20 inches from the edge of the shaft. This latter had a rectangular section of 6¼×13 feet. The congelation lasted 50 days, and the block of ice obtained extended, at the surface, to five feet back of the tubes. The volume of water forced into the tubes by the pump amounted to 70 gallons per minute, representing 35·32 cubic feet per tube and per hour. The total cost of the freezing, properly so called, was about forty-six dollars per foot, to which must be added the cost of excavating, say about three hundred dollars, as well as the amortizement of the plant, which carried the total cost up to about one hundred and fifty-three dollars per foot. These figures might doubtless have been sensibly reduced, as Mr. Lebreton remarks, for it is found by calculation that the tubes might have been spaced 5 feet apart, so as to diminish their number, and prevent congelation within the section of the shaft.

It must be observed that the cost above indicated differs but little from that which would follow an application of the ordinary methods to earth of average consistency, but is much less than it would be in an application of such methods to shifting and water earth. This method, then, appears to be peculiarly well adapted for the excavating of such soils, so long as the stratum is not too thick, and there is reason to believe that it will receive numerous applications in the future, not only for sinking mine shafts, but also for founding bridge piers, and perhaps even for driving oblique or horizontal galleries.—*La Nature.*

[Continued from SUPPLEMENT, No. 536, page 8556.]

THE USE OF TORPEDOES IN WAR.*

By Commander E. P. GALLWEY, R.N.

SPECIAL TORPEDO-SHIPS.

THE numerous special torpedo-ships now built or building is another result of Mr. Whitehead's invention. The one that has caused most attention of late is the much-abused Polyphemus, a model of which is on the table. Undoubtedly she has been a costly experiment, but at the same time a very successful one. The arguments in her favor are:

I. That she has a very high speed, combined with fair maneuvering power.

II. That she can discharge her torpedoes with certainty either ahead or on the beam, when proceeding at full speed. See Diagram 7, Plate II.

(This diagram represents the result of the last ten shots fired from the Polyphemus during recent experiments; and I think there is no doubt that in the new vessel of the same type, about to be built, we shall greatly exceed the results already obtained.)

III. That her crew and weapons of offense are protected by the most perfect armor possible, viz., ten feet of water.

IV. That she only presents a mark of four feet above the water-line.

What her special functions will be in action I leave to more competent officers to deal with; but I argue that in the Polyphemus we have one of the most formidable engines of naval warfare yet built, and a type of ship which, unless some better protection than we have at present can be found for the bottom of an ironclad, may necessitate the abandonment of these monster ironclads in modern fleets.

With what weapon is the ironclad going to vanquish the numerous torpedo rams that are being built in every country, and of which class as a torpedo-ship alone the Polyphemus is, I maintain, the most formidable? Undoubtedly all experience with heavy guns points to the fact that the guns of an ironclad cannot be depended on to hit, much less stop, a vessel moving at high speed, and showing only four feet of surface above water. She is proof against machine-guns, and being smaller, handier, and faster than most ironclads, should have the best chance with her ram, more especially as it is provided with a weapon that at the very least can be, and has been, discharged hundreds of times with the greatest certainty to a distance of 300 yards. If fitted with torpedoes, the ironclad has one weapon to fall back on, and that is the torpedo, for the Polyphemus must come within range of these in order to discharge her own, and being a good length, would make a fair target. It would then become a question of speed and maneuvering power, as the fastest and handiest ship would be able to place herself in those positions where she could use her own torpedoes to the greatest advantage, and be less likely to be hit herself.

In special torpedo-ships of all classes, the conning-

* A lecture delivered before the Royal U. S. Institution, March 6, 1886.

tower is the place of all others to be well protected, as not having guns to be disabled or a man to be seen, no doubt the fire of the machine-guns will be concentrated on this spot. The greatest care, therefore, should be taken that the accident which deprived the Huascar of her captain and steering gear, twenty minutes after the action began, should be carefully guarded against. I should therefore, if possible, give all special torpedo-ships at least three positions from which the ship can be steered and torpedoes fired, keeping in view the fact that her main chance of success lies in the small mark she presents. If a submarine ship, armed with locomotive torpedoes, be ever built, then we shall have the most formidable antagonist for large ironclads it is possible to imagine, and the nearer the special torpedo-ship can resemble the submarine boat, the more formidable does she become.

Of the numerous other special torpedo-ships which are built or building, I am afraid the time is too short to be able to discuss them; I have therefore only called your attention to the one which I suggest is the most important.

TORPEDO-BOATS.

Many lectures have been given in this institution on torpedo-boats, describing their general behavior, size, etc.; so that I will not take up your time by describing any particular type of boat.

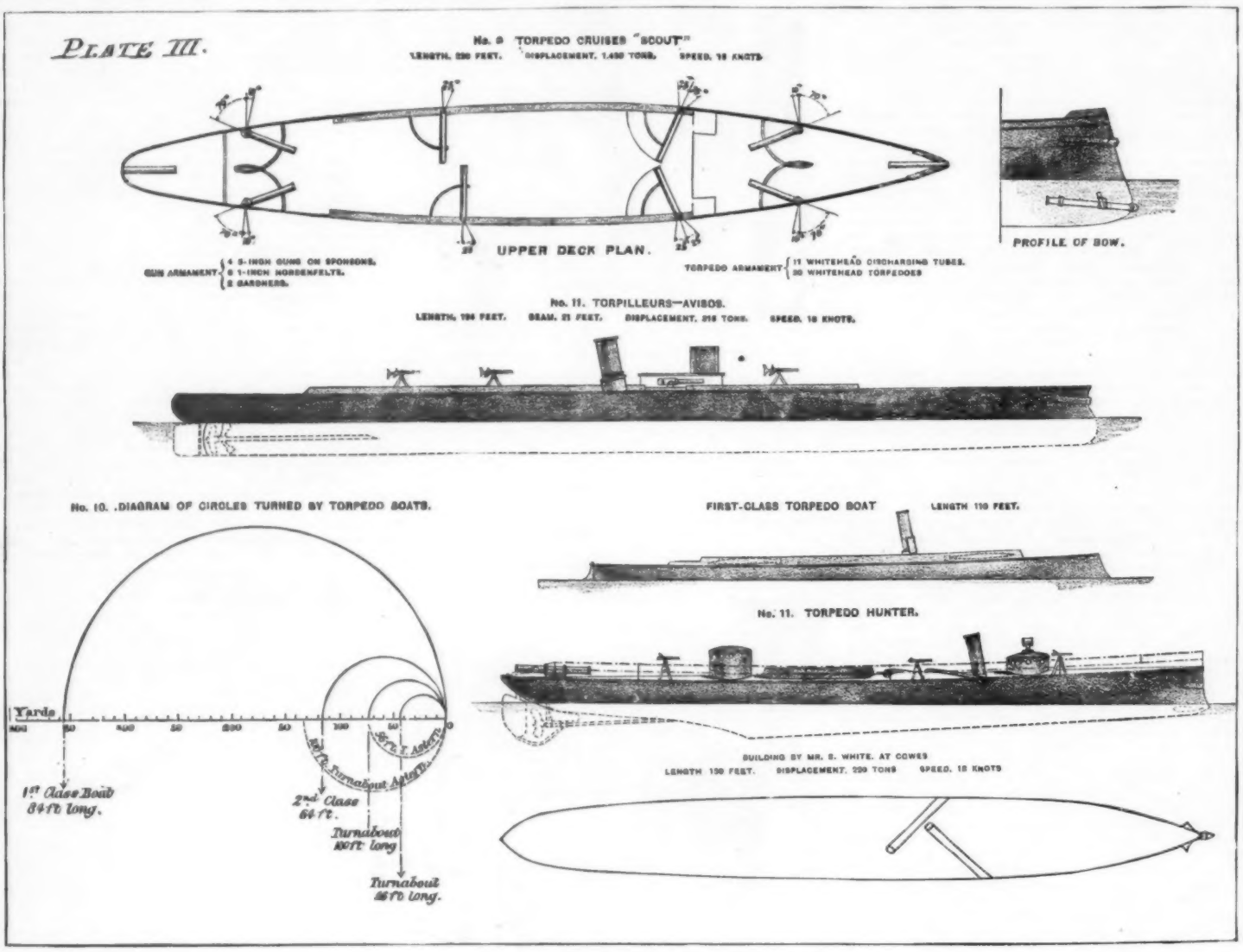
the crew and wear and tear to the boats. Possibly it may be very advantageous at times to be able to send a few of these boats to some foreign port, and there is a much greater chance of the boats arriving together in less time and in better order if they are hoisted into a parent ship than if they steam out by themselves. When once out at the port they are required at, they can be trusted to take care of themselves.

But in designing boats for coast defense, it should not be lost sight of that their value is enhanced by the ability, should circumstances admit of it, of dispatching them in a ship to any part of the world quickly and without risk. Speed in a torpedo-boat no doubt is of the first importance; but I would not lose sight of other points almost as important, for the sake of maintaining this speed, and, after all, the greatest speed gained on the measured mile is seldom attained afterward; and when will it be used? I think that in nine out of ten attacks it will be used for a very short time only. In the first place, if boats are making a simultaneous attack, they will go slow, as near as they can, and the signal for full speed will be the first shot fired by the enemy. The duty of the commander of a flotilla is to bring his boats as near as he can without discovery, and his orders should be, "Keep close to me until the first shot is fired, then go full speed and act for yourselves." In comparing the qualities of a torpedo-boat, the turning power, seaworthiness, etc., bors where electrical mines must be used, which have the disadvantage of taking long to lay down and requiring fine weather to do it in, and which, when down, would not in most cases prevent the enemy shelling the town.

I think most people conversant with the enormous amount of *materiel* and trained men required to lay down and keep in order a system of electrical mines sufficient to defend a large port will agree with me that it is an impossibility to defend all our harbors which are liable to an attack, and besides which at some of the northern ports for weeks together the weather is so bad that electrical mines could not be laid down, no matter how highly trained your men are. Torpedo-boats are, I should say, peculiarly well adapted for naval volunteers, as most of these latter have been brought up to the use of boats, and the other knowledge they could soon pick up. I should very much like to see a boat lent to one of the Naval Volunteer Corps, and see to what degree of proficiency they would arrive.

One thing is certain, that the efficiency of a torpedo-boat mainly depends on the amount of practice and experience the crew have had in her. A nation with no boats to practice with in time of peace will find but little value in the few she may hurriedly get together in time of war. I do not mean so much in the use of the Whitehead as in the art of handling the boat, keep-

PLATE III.


No. 9 TORPEDO CRUISER "SCOUT"
LENGTH, 230 FEET. DISPLACEMENT, 1,400 TONS. SPEED, 16 KNOTS
UPPER DECK PLAN.
PROFILE OF BOW.
GUN ARMAMENT { 4 9-INCH GUNS ON SPONSONS. 6 1-INCH NORDENFELTS. 2 GARDNERS.
TORPEDO ARMAMENT { 11 WHITEHEAD DISCHARGING TUBES. 20 WHITEHEAD TORPEDOES
No. 11. TORPILLEURS—AVISOS.
LENGTH, 184 FEET. BEAM, 21 FEET. DISPLACEMENT, 310 TONS. SPEED, 16 KNOTS.
No. 10. DIAGRAM OF CIRCLES TURNED BY TORPEDO BOATS.
Yards
1st Class Boat 84 ft. long.
2nd Class 64 ft.
Turnabout 100 ft. long
Turnabout 86 ft. long.
FIRST-CLASS TORPEDO BOAT LENGTH 110 FEET.
No. 11. TORPEDO HUNTER.
BUILDING BY MR. S. WHITE, AT COWES
LENGTH 130 FEET. DISPLACEMENT, 220 TONS SPEED, 18 KNOTS

THE USE OF TORPEDOES IN WAR.

The principal use of torpedo-boats in time of war no doubt will be:

First—for coast defense.

Second—for the protection of the fleet from torpedo-boat attacks.

Third—the attack of the enemy's fleet.

Torpedo-boats may be divided into two classes: those which are carried by ships, and those capable of keeping the sea and cruising on their own account. The latter are the boats which are now being built by foreign governments in large numbers. All foreign boats with which I am acquainted are constructed to fire only two torpedoes, both right ahead, while it is the opinion of our officers that beam fire is of more importance. The success of a torpedo attack will depend largely upon the number of boats which can be brought simultaneously to deliver it. As regards the number of boats that can be brought up to deliver a simultaneous attack, I look upon eight as the proper number, for I do not believe it is possible to keep more than this number together at night.

For coast defense boats, I should say a length of 110 feet is quite sufficient; boats of this size have kept the sea when ironclads have had to take shelter. The smaller the boat, the greater number can you have of them for the same price; they are handier and present a less mark. I think, however, that boats of 110 feet and about 60 tons displacement are, on the whole, the most useful size for coast defense, and they are also not too big, if you provide suitable ships, to be carried to any part of the world. That they can go by themselves, if necessary, is proved by the fact of the Childers, a 113 foot boat, steaming to Australia by herself last year. But it entails very great hardship to should be taken into account, and not, as is generally the case, speed only.

The boat shown on Diagram 8 is the one now building by Messrs. Thornycroft & Co. for the English Government; and though she carries five torpedoes always ready for discharge, she is still not too large to come under the definition of a coast defense torpedo-boat. In this boat, speed has been sacrificed to a small extent in order to carry a bow-tube, and also two complete sets of torpedo-tubes, which can be trained round on steel conning-towers to any desired angle. In her, therefore, we shall be able to fire one torpedo ahead, and four on either beam, so that she is able to discharge almost simultaneously five torpedoes at her enemy, and this advantage surely compensates for the loss of a little speed, even if we do not take into account the advantage gained by having two conning-towers with a separate steering engine in each.

For harbor defense the torpedo-boat is becoming superior to the stationary mine; I should not be surprised, therefore, if before long it superseded it altogether. After many years we do not seem to have made any great advance toward the perfection of submarine mines; they cannot be laid far enough from the shore, and any modern gun can throw a shell far beyond the distance any electrical mine can be laid. The class of mechanical mine already described may no doubt be sometimes used with great advantage, but in the majority of cases the use of mechanical mines in our own harbors is impossible, as they close the harbors to friend as well as foe, and one of the principal objects of our coast defense should be to keep the harbors open.

These remarks apply principally to mercantile harbing company with others on a dark night, and an accurate knowledge of the coast. The Whitehead does not require much knowledge to be able to use it; its mechanism may be complicated, but so long as the crew can put it into its tube and pull the firing handle when the sights come on, but little else is necessary.

Last summer, when a fleet of torpedo-boats was attached to the Channel fleet, then under the command of His Royal Highness, the following experiment was tried: Seven boats were lying one evening in Lulworth Cove, each of which was able to fire one torpedo; before dark the torpedoes were charged, and placed in their tubes, the tubes laid on a given angle, and the sights adjusted. Nothing more was done to the tubes or torpedoes till we attacked the fleet at 11 P. M., in Portland, when, as the boats steamed past the Hecla, each officer pulled his firing lever as his sights came on.

The result was that three torpedoes struck the Hecla side by side in line with the funnel (the spot aimed at), and three more struck about 12 feet farther aft in the engine-room compartment.

In this case we had experienced lieutenants in every boat, each officer having had a month's constant practice in the boat under his charge, but supposing these officers had not been available, which is likely in time of war, it is quite possible that any man who had equal practice with his boat might have done as well, though not scientifically instructed in the use of the torpedo.

There is, I know, a very prevalent idea that the Whitehead is a very delicate weapon, difficult to work and keep in order. That this is not the case I think is shown by the following experience, gained during the Russian maneuvers last year. The Russians had divided their fleet into two squadrons, who were to at-

tack each other in any way they thought best. One squadron when searching for the other passed within 200 or 300 yards from some fishing boats, the crews of which were busy with their nets. Suddenly a torpedo fired from one of these boats struck the Russian flagship under the quarter. Not only did it strike, but a small charge in the head was also exploded by the action of the pistol, showing that undoubtedly a larger charge if it had been used would have exploded also. So the Russians were able to keep this so-called fragile and delicate weapon in a small fishing boat, and were able to discharge it with accuracy and success.

THE PROTECTION OF FLEETS.

In 1876 Mr. Barnaby, in a paper he read before the Institution of Naval Architects, said, while referring to the defense of fleets from torpedo-boat attacks, that "the assailants ought to be brought to bay before they get within striking distance of the ironclad by consorts armed like the attacking vessel, with the ram and torpedo. Each costly ironclad ought to be a division defended against the torpedo and the ram by numerous smaller but less important parts of the general forces."

At the time that paper was read the idea was warmly commended by such authorities as Admiral Sir S. Robinson, Sir E. Reed, Mr. Scott Russell, and many others. Since 1876, this statement of Mr. Barnaby's has often been quoted by various authorities as an indispensable necessity for a modern fleet of ironclads. The other day at this Institution, Sir E. Reed said that "the craft we want is a torpedo-boat catcher and destroyer." The French certainly indorse this idea, for they have now on the stocks nine vessels of this class. I think that in the recent proposed additions to the navy, the omission of this class of vessel from the official programme came as a surprise to most naval officers, especially as the absolute necessity of having them was pointed out ten years ago, and since that time the immense increase in the number of boats possessed by foreign powers has made the necessity for this class of boat greater than ever.

The class of vessels represented by the Scout are not the class required; they are, I think, too big and costly, and are too important an item of the fleet. The Scout (Diagram 9, Plate III. would be an object of attack, and her destruction would compensate the enemy for the loss of one or two boats.

The only boat in England that I know of that comes up to the definition of a torpedo-boat destroyer is the one building by Mr. S. White, at Cowes. This boat is on Mr. White's turnabout principle, which gives extraordinary maneuvering powers, *both ahead* and *astern*. There is a model of this class of boat on the table, and Diagram 10 shows her turning circle as compared with a first and second class boat. At first there might be some doubt as to the success of these boats when they got to a large size, but they are now past the experimental stage, as a boat recently tried, which was 90 ft. long, 17 ft. beam, and 90 tons displacement, proved as satisfactory as the 56 ft. boat, making a complete circle in 75 yards ahead and 130 yards *astern*.

Diagram 11 shows a rough sketch of Mr. White's boat, also the size of the French boats. The dimensions given of this latter boat are, I believe, correct, but the drawing has been made from a written description, in order to illustrate its size as compared with the 110 ft. boat shown in the center.

Mr. Yarrow is also about to build for the Austrian Government two boats 135 ft. long, with an estimated speed of 24 knots light and 22 knots fully loaded.

A torpedo-boat destroyer to be satisfactory must be superior to the torpedo-boat in maneuvering powers, size, strength, and if possible speed. The present idea seems to be to try and make one boat do both duties, that is to say, coast defense and accompanying a fleet to sea. The result is, we get a boat that is not the best suited for either purpose. For coast defense she is too long, draws too much water (7 or 8 feet), and is unhandy, while to keep the sea she is not big enough, nor superior enough in size to the boats she will have to encounter. What I would like to see would be boats of 110 ft. long for coast defense, and about 50 tons displacement, and torpedo hunters of 200 to 300 tons displacement, on the turnabout principle, to accompany our fleet to sea.

DEFENSE BY MACHINE-GUN FIRE.

As regards machine-gun fire, its value has yet to be proved; it can only be decided when war breaks out. Models of torpedo-boats fired at on a clear and calm day are generally riddled with bullets; it would be surprising if they were not, for as long as you can see the bullet strike on the water you can play on the boat if she is stationary with considerable certainty.

But these are not the conditions of a torpedo-boat attack, as it will generally take place at night or in thick weather, and if you cannot see the bullets strike, you will not know whether you have the right elevation or not till the torpedo strikes you or the boat is stopped.

I have never yet heard of an experiment in which the boat has been seen at night over 800 yards. Ask any one who has seen three or four fast boats approaching a fleet at night how far they think they can be seen. Read the accounts of the experiments carried out in Russia, Germany, France, Austria, and Denmark; they all point to the same conclusion, that boats cannot be seen distinctly enough to be fired at before they are within range of their torpedoes. I myself saw last summer a fleet of six second-class boats get within 50 yards of the flagship of the Channel Fleet before they were discovered, although six electric lights were employed in searching round the fleet. The experiments carried out in England in May, 1880, by firing at models of torpedo-boats, show the number of shots which may be expected to hit a torpedo-boat.

In these experiments the mean result of six runs showed that the mean number of hits made from a ship steaming at 6 knots when firing at a stationary target was as follows, viz.:

16 per minute from the Nordenfelt gun, and
6 per minute from the Hotchkiss.

The guns had the advantage, however, of continuing the firing up to a range of 100 yards, and the observers who were stationed near the target remarked that nearly all the shot that were fired *under* 300 yards struck the boat. In the report on these trials the D. N. O. remarked that he does not consider that the guns would have been successful in stopping a boat at over 1,000 yards, even in daylight.

So if we accept these conditions, the time the boat shown in Diagram 6 as attacking the Edinburgh would have been under fire would be 30″. And by the above experiments she would have received eight shots from the Nordenfelt and three from the Hotchkiss gun.

But the conditions in this case would be much more favorable to the boat, as she would not approach nearer than 400 yards before firing her torpedo, and the distance would diminish at a combined speed of 33 knots instead of 6. Of course in action more than one gun would be firing at a time, but probably more than one boat would be attacking; and though no doubt it would be a hazardous enterprise in the day-time, it is far from hopeless, and at night-time the boat would have the best chance. Anyhow, I think it is generally recognized among naval officers that we cannot trust to machine-guns alone.

The question then is, "What is the best way of protecting a fleet?" and the answer seems to be, "With torpedo-hunters," as proposed by Mr. Barnaby ten years ago, supplemented by either—

First, constructing the ship so that she is unsinkable, or

Second, by the use of nets or some other device for keeping the torpedo off the bottom altogether.

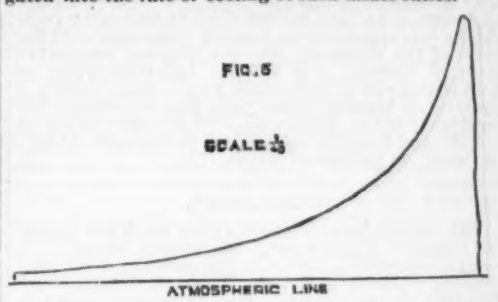
As regards the first, if there is a possibility of success, by all means carry out the most exhaustive experiments at any cost, as it is of the utmost importance to us as the nation who ought to have the largest number of ships. I cannot offer an opinion as to the possibility of constructing a ship to withstand the concussion of a torpedo. But I would like to point out that after the experiments against sections of the bottom of the Hercules, the charges of all locomotive torpedoes were reduced to 30 lb., as this amount was found by experiment to be sufficient to fatally damage any ship afloat when exploded at a distance of four feet from her side. Since then, as more attention has been paid to watertight bottoms, etc., the charges are again becoming larger, and there is no difficulty in increasing them still more. Even supposing that you do render the ship by means of ironclad bottoms or other devices free from the danger of actually sinking at once, previous experiments seem to show that she will probably be disabled, so that the main object of the attack would be gained.

If any perfect protection against the torpedo be ever found, it will be something that will keep the torpedo off the bottom altogether. At present there is no satisfactory way of doing so. The nearest approach to any arrangement for this purpose are the nets supplied to our navy, and although they cannot be used under every circumstance, still in many cases I am sure that they will be very valuable, and if practice with them is diligently carried out, that we shall soon see a vast improvement in their general adaptability. Their use in a fleet action is as yet improbable, so that we ought to meet torpedo-boat with torpedo-boat, or better still with torpedo-boat destroyers, for that a fleet action will commence with a boat attack seems probable, indeed certain, or why are all nations building fast boats large enough to accompany the fleets to sea, one of which is attached to each large ship when performing fleet maneuvers, if this is not what they are to be used for?

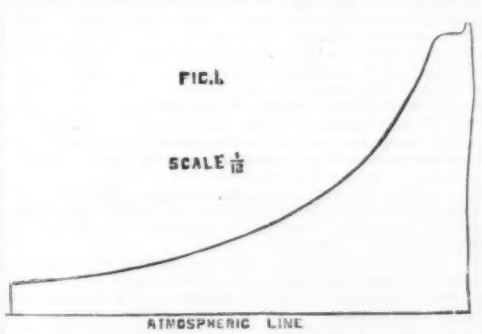
In conclusion, I fear that many important points in connection with torpedo warfare have not been discussed in my paper, and that it illustrates more the present condition of the weapon than its probable use. I have necessarily limited it to those points which I suggest are most important, for which the time available for so large a subject must be my excuse.

EXPLOSIVE FORCES IN GAS ENGINES.

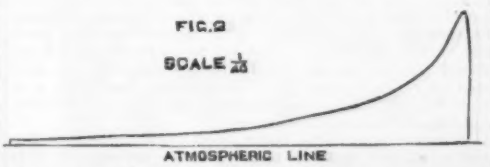
AT a recent meeting of the Dundee Mechanical Society, Mr. Geo. C. Douglas, Douglas Foundry, read a paper "On the Explosion of Gases, and the Rates of Cooling of various Mixtures of Coal Gas and Air." It was illustrated by experiments. He stated that he had obtained diagrams with ratios of gas to air varying from $\frac{1}{6}$ to $\frac{1}{12}$. A two-chamber eudiometer was used, the one chamber being separated from the other by means of a diaphragm of oiled paper, which was broken through by the explosion of the gas and air in the adjacent chamber when the mixture was ignited by the electric spark. An indicator, moved by clockwork at a uniform speed, gave a diagram showing the rate of cooling. Three of these diagrams are given. He stated that, so far as he knew, he was the first who had investigated into the rate of cooling of such dilute ratios.



Maximum pressure, 63 lb. per square inch above atmosphere.
Mixture, 1 volume of gas to 10 volumes of air.
Temperature before ignition, 5° C.
Temperature after ignition, 1176° C.
Time taken to describe diagram, 4 seconds.



Maximum pressure, 21 lb. per square inch above atmosphere.
Mixture, 1 volume of gas to 21 volumes of air.
Temperature before ignition, 7° C.
Temperature after ignition, 400° C.
Time taken to describe diagram, 4 seconds.



Maximum pressure, 33 lb. per square inch above atmosphere.
Mixture, 1 volume of gas to 20 volumes of air.
Temperature before ignition, 5° C.
Temperature after ignition, 618° C.
Time taken to describe diagram, 4 seconds.

ISAAC NEWTON.

ISAAC NEWTON was born on the 25th of December, 1642. His father had died at the age of thirty-six, several months after his marriage with Harriet Ayscough. Isaac began his eventful life in the village of Woolsthorpe, in the parish of Colsterworth, Lincolnshire, four miles south of the city of Grantham. It is an historical fact that he was so small, as his mother used to say, he could be completely hid in a quart pitcher; and he was naturally so feeble that he was not expected to live a day. But fortunately for posterity, Providence had decreed otherwise; and the powerless child developed into a man who lived in almost constant good health more than eighty-four years, thus surpassing the average duration of human life.

He was about ten years old when he entered the public school at Grantham; still, as he himself acknowledged in after days, Master Newton was neither diligent nor attentive in school, and for more than a year constituted with several of his peers the bottom of his class. One day, however, a lad who was looked upon as the best student of the school struck him such a blow on the breast that the poor boy felt it for some time afterward. Newton thereupon sought revenge. Since his opponent was by far his superior in bodily power, our fellow determined to beat him mentally. Aided by his natural ability, he began to work so diligently that henceforth we find him at the head of his school. This incident, unimportant as it may seem, served to inspire the boy, who, so far, had been almost passive, with inclination to action and occupation, and to develop the chief traits of his character.

Toward the end of his three years' stay at that public school, he spent his leisure hours principally in practical mechanics, in which he soon became very dexterous. He constructed a windmill, a water-clock, and also a wagon that was put and kept in motion by the passenger himself. Seldom do we find him taking part in the boisterous games of his young schoolmates, but instead he was always ready to assist them in making several very ingenious toys, kites, and the like.

He was continually occupied in drawing, and the walls of his room were fairly covered with sketches and pictures made by himself.

Even the muse of poetry he affected; and when a man, he loved to look back and recount to his friends that when as yet at Grantham he wrote some pretty verses.

In the year 1656, when fourteen years old, his mother took him home, to help her in the affairs of her farm. But young Newton was positively averse to such things, and preferred the reading of some old book or other, borrowed from a neighbor, the elaboration of a model, the construction of a new windmill, and similar occupations, to the drowsy task of tilling the ground. Thus he was often seen walking among the fields with arms folded and mind wandering, while the flock intrusted to his care, being left to itself, had a splendid time destroying fields and meadows and going wherever it pleased. On such an occasion he was found by his uncle, William Ayscough, a minister, sitting behind a hedge, with a treatise on geometry in his hands. This moment decided his whole future! His uncle persuaded Mrs. Newton to send the boy to Trinity College, Cambridge, convincing her that he was good only for studying.

Newton entered that school on the 5th of June, 1660, at the age of eighteen. The young man, who was destined to remold all science, then touched the first steps to her temple, in order to be at last admitted to her awful presence. Without the advice of learned friends, without even knowing which were the best books, he possessed less than the average knowledge when he entered the university. He had spent his time in playing with machines, and had followed only his love for practical experiment; but it was, perhaps, better that he brought with him none of the prejudice and premature opinions which, though generally false, still, when deeply engraved on the youthful mind, are so difficult to erase in order to make room for sound and correct views.

In this institution Newton's mind was developed more perfectly; there already he displayed his talent in discovering those three grand truths which have immortalized his name, viz., about light, the infinitesimal, and gravitation. From the very beginning of his studies he devoted all his attention to mathematics. Euclid was merely read like a novel, and regarded as too easy! He looked upon the theorems as so many axioms, which are comprehended the moment they are heard. Without further preparation he turned immediately to Descartes' profound work on geometry; soon after he took up Saunderson's Logic, and then Kepler's writings on optics and astronomy. While reading these by no means simple works, he used to make extracts of them, and so fast was his progress in these sciences that his tutor soon declared he could not teach him any more, and that this young man was better fitted to give than to receive advice!

In the next year, 1661, he became subsizar (*i. e.*, a student who waited on the scholars or free students), but not until 1664 a true scholar. In 1665 the degree of bachelor of arts was conferred upon him; two years later he became younger professor, the next year elder professor; and at last, in 1669, when twenty-seven years old, he was appointed professor of mathematics in the place of the renowned Barrows, who had resigned in favor of Newton. Till 1695, for twenty-six years, he kept that position, after which he was made warden of the mint, in London. Four years later he obtained the presidency of the royal mint, with a yearly income of £15,000, and kept this position till he was carried away, by death, on the 20th of March, 1727.

JULES JAMIN.

THE Academie des Sciences, a body much less numerous than our Royal Society, has latterly sustained an exceptional series of losses in the persons of its most eminent members. Dumas, Thenard, Wurtz, Milne-Edwards, Robin—to name only those best known in this country—have passed away, leaving their places to be filled and their researches to be continued by others. The latest, and certainly not the least regretted of these losses, is that of Jules Jamin. Called to the Perpetual Secretaryship on the death of his illustrious master, Dumas, he discharged the onerous and delicate funtions of his high office to the general satisfaction of his colleagues and of the scientific world; and, though in his sixty-eighth year, his demise was no less unexpected than unwelcome.

Jules Jamin was born at Termes, in the Ardennes, May 31, 1818. He commenced his education in a private school in the town of Vouziers. Thence he passed to the College of Rheims, gaining the highest honors, and in 1841 he left this establishment as "first agrégé" in the physical sciences. His subsequent progress was decisive. He filled with the highest credit the professorial chairs of physics at the Ecole Polytechnique, at the Sorbonne, and at the Faculté des Sciences. As a lecturer his success was remarkable. His clearness of exposition, his power of rendering even the most complicated theories clear to his hearers, will never be forgotten by his former pupils. The same

JULES JAMIN.

attributes are displayed in his two systematic works, *Traite general de physique*, which was a reproduction of his course at the Polytechnic, and his *Petit traite de physique*, where he explains the modern theories of the phenomena of light, heat, and electricity with admirable lucidity.

His researches embraced nearly all departments of physics. Perhaps to English electricians he is best known through the magnet of peculiar construction which bears his name, and his electric candle, which burns point downward and is self-igniting. Besides his labors in optics, magnetism, and electricity, which constitute his highest claim to the notice of posterity—we remind our readers here that he was the first to complete a rational study of magneto-electric currents—his researches on the compressibility of liquids, on capillarity, hygrometry, specific heat, the critical point of gases, etc., attest the originality and the fertility of his genius. With him, as is happily said by his eulogist, M. L. Troost, teaching and discovering were identical. Nor must we forget that several of his pupils have been ound ready to follow in his footsteps. Thus Blondlot has produced a valuable memoir on the "Capacity of Voltaic Polarization," and Benoit has investigated the resistance of metals.

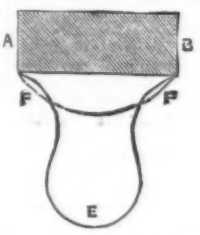
It may not be superfluous to remark that though a laborious and successful physicist, he was more; he was known also as a botanist and a geologist, and he found time also for metaphysics, literature, music, and the fine arts. There exist paintings from his hand not without merit. He insisted on the advantages of a closer approximation between the artist and the *savant*, united as they are by the common necessity of observing the optical appearances of natural objects. We cannot, in concluding this brief sketch of the illustrious dead, do other than express to our French fellow-laborers in the cause of science our profound sympathy for the loss they have sustained.—*Electrical Review; La Nature.*

CAPILLARY ATTRACTION.

PROFESSOR SIR WILLIAM THOMSON lectured recently at the Royal Institution on "Capillary Attraction." Dr. William Huggins, F.R.S., presided.

The speaker said that it had been known from time immemorial that heaviness depends upon mutual attraction between different portions of matter, but that before Newton's discovery of universal gravitation it was not suspected that heaviness is due to attraction at a distance between two portions of matter, which act upon each other in obedience to the law of the pull varying as the square of the distance. Cavendish proved experimentally that this law holds good with two small portions of matter not far apart, but men had been willing to admit infractions of the law at still smaller distances. His question that evening was whether the law held good at very small distances, down, say, to the hundred-millionth of a centimeter. Those who admitted the infraction of the law at very small distances were not ready to admit its infraction at very great distances. If it were found that it was not necessary to explain the atomic and molecular phenomena of cohesion and capillary attraction by the abrogation of Newton's law of gravitation when small distances were concerned, then they were not forced to admit such deviation. Capillary attraction was so named because it was first recognized in hair-like tubes, which were not indispensable for the exhibition of the fundamental phenomena. Quincke concluded that molecular attraction becomes sensible at distances of about fifty micro-millimeters, and his conclusion is confirmed by the discovery of Reinold and Rücker that the black film always formed before a soap bubble breaks has a uniform or nearly uniform thickness of about eleven or twelve micro-millimeters; the black film has an abrupt commencement and somewhat permanent stability, which evidently depends upon molecular heterogeneousness. It is conceivable, he argued, that gravity may be the force by which the phenomena of cohesion, consequently of capillary attraction, are produced; all that is necessary is, putting aside for the moment ideas about the motion of atoms, that the atoms should have sufficient density to increase the force of gravity to any desired extent. It is a question of intensity of density. He, Sir William Thomson, had put forth this idea nineteen years ago, but it attracted little attention at the time, nor did he think that it deserved to do so, for molecular motions must be taken into consideration. He then called attention to the result of some mathematical investigations of the attraction exerted by drops of water when free from the action of gravitation, to the effect that he had found $\frac{2}{55}$, or $\frac{1}{28}$, of a centimeter-gramme of work per square centimeter of diminution of surface. This is precisely the result which would have been obtained if the water had been absolutely deprived of the attractive force between water and water, and its whole surface had been coated over with an infinitely thin contractile film possessing a uniform contractile force of $\frac{1}{28}$ of a gramme weight per lineal centimeter.

He proceeded to show a few experiments, including one in which a large flat ring of wood, A B, like that of a sieve, had a piece of thin sheet India-rubber stretched over its lower orifice; water was then poured in, and



the imitation drop of liquid, 2 ft. or 3 ft. long, E, was formed. He showed that this drop had two positions of stability, for by pressing it upward with his hands it would also rest steadily in the position denoted by the dotted line, F F. In water-drops, he said, there is no actual external film, but the surface tension acts in the same way as if there were one.

In relation to the surface tension of fluids, he said that his brother, Professor James Thomson, had been the first to explain the phenomenon of the "tears of wine," to which Solomon perhaps alluded when he said that wine "moveth itself aright," which in the new version is altered to "goeth down smoothly." Aqueous liquids containing 20 per cent. of alcohol show the effect best. Stronger and weaker mixtures do not show it so well. A large sheet of glass in an inclined position was painted across horizontally with a 20 per cent. mixture of colored alcohol and water as a broad liquid band, and the tears on a large scale were seen running from the top of the band downward, the speaker remarking, "Pull alcohol—pull water." He said that the vapor of alcohol passes off quicker than the vapor of water; the relative volume of water in the liquid is thereby increased, and its surface tension likewise, the result being that it pulls harder at the liquid below, and draws it up until equilibrum is restored.

In another experiment he showed that a film of water would recede upon the approach of a camel's hair brush charged with ether, the ether vapor driving the water with some force before it.

He said that diffusion was the result of negative surface tension, and that as great a negative pressure had been observed as 100 atmospheres, or 1 ton per 10 square centimeters.

DU ROCHER'S ELECTRIC MEGALOSCOPE AND PILE.

THE efforts that have been made to directly examine the cavities of the human body, principally the stomach and bladder, date back to a distant epoch. Nelaton was one of the first to pay attention to this question, and his name alone proves what importance is attached to its solution. The researches that have been made, however, have led to no result, and it required the invention of the incandescent lamp, and especially the reduction of the globe of the latter to a diameter of 3 or 4 millimeters, in order to solve the problem in a practical manner.

Different apparatus have been constructed for the various organs that it is of interest to examine by this process. Several have been described in this journal, and, although these were adequate in all cases in which the eye, either directly or by reflection, could see a sufficiently wide surface of the cavity to be examined, they became entirely inadequate when it was a question of an organ like the stomach or bladder, where, despite an illumination of the entire cavity, the eye could perceive but a single point through the tube or sound that served for the introduction of the lamp. Under such circumstances, only an imperfect diagnosis can be made, since it is then inpossible to estimate the position or size of a urinary calculus or the nature of lesions or ulcerations of the stomach. All the apparatus that have been devised up to the present have had the same defect, viz., that the instrument's field of observation is too limited. In this respect the apparatus that Dr. Boisseau du Rocher has recently presented to the Academy of Sciences, the Academy of Medicine, and different other learned bodies, is a great improvement; and although in its electrical arrangements it resembles its predecessors, it differs totally from the latter in its optical ones, these being such that it is possible to see a surface of a mean diameter of 15

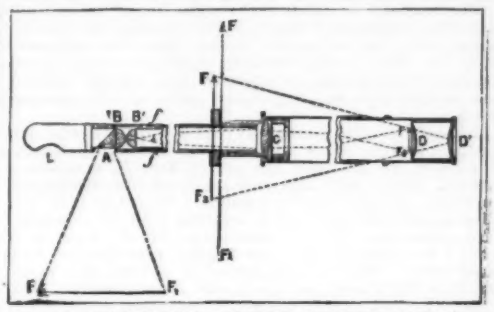


FIG. 1.—DIAGRAM OF THE MEGALOSCOPE.

centimeters through a sound of very small diameter. The name "megaloscope," given this instrument, means, "to see an enlarged image" (μεγας "large," εἰκών "image," σκοπειν "to see"). The form of the image varies, of course, according to the nature of the organ to be examined. We shall not enter into the details of the instrument, but shall merely give a diagram (Fig. 1) of one of its simplest forms, which will serve for describing the optical principle.

At the lower extremity of the instrument, in a cavity, L, forming a reflector, is placed the incandescent lamp. A little above this, and on the same side, there is an aperture, A, in which is placed a prism 3 mm.

FIG. 2.—DR. DU ROCHER'S PILE.

wide on each side. In order to enlarge the field of exploration, two lenses, B and B', of short focus, are placed immediately behind the prism and receive all the divergent rays that emanate from the illuminated part, FF', in order to give a microscopic image, *ff'*, reversed in space; that is to say, an exceedingly reduced image of the object examined. It is only necessary, then, to look at this image with a telescope, CD, mounted at the upper extremity of the instrument, in order to make it of normal size.

The objective, C, gives a first real image, FF_2, reversed and enlarged, of *ff'*; and the eye-piece, D, gives a second, and aerial and virtual one, FF_1, still further enlarged. As just remarked, the lenses, C and D, are

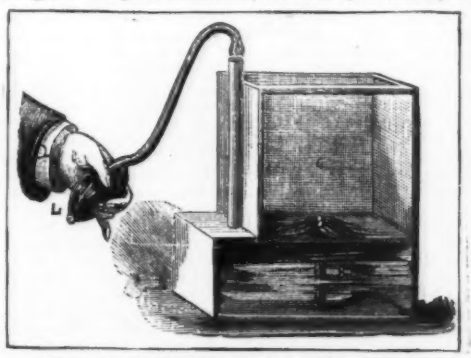


FIG. 3.—PRINCIPLE OF THE PILE.

so calculated that the sum of the two magnifications gives the object examined its normal size. If we wish it of larger dimensions, we add an objective, D', that gives a greatly enlarged image, FF_4.

Such is the optical arrangement of these instruments. It is to be remarked that it is almost useless to diminish the diameter of the tube within certain limits, for the lenses, BB', being hemispheres, the length of the foci diminishes with the diameter, and the field observed is so much the wider. In practice, the diameter adopted is about 6 mm. In the second place, it is to be observed that focusing, properly so called, is unnecessary, since, as the reduced image that forms in space moves but

slightly in proportion to the greater or less distance of the object observed, the observer's eye itself unconsciously does its focusing.

In order to render the apparatus complete, it was necessary to furnish the practitioner with a source of electricity for working it. Dr. Du Rocher found out by experience that all piles that are more or less portable, and that are designed for medical purposes, are not always convenient, and therefore devised the ingenious arrangement shown in Figs. 2 and 3. This consists of a single liquid bichromate pile, which was especially designed for galvano-cauterization, but which a reduced size, provided with a rheostat, G, placed in the cover, permits of employing when it is a question of lighting the megaloscope. It consists of two troughs, C and B, placed near each other (Fig. 3). The first of these, C, which is open at the top, receives the zinc-carbon elements, while the second, B, which is entirely closed, is connected with the first by a tube which descends nearly to the bottom and serves for the introduction of the exciting liquid. To a second tube that starts from the top is fixed a rubber bulb through which air may be introduced. The pressure then forces the liquid to rise, and to immerse to a greater or less degree the elements placed at C. In order to cause the liquid to descend again into the lower vessel, it is only necessary to give an outlet to the introduced air, and to do this we have merely to remove the bulb from the tube. This arrangement is very simple and ingenious, and renders the pile transportable, since after the liquid is once in the lower compartment it cannot escape, even if the pile be completely overturned.

Dr. Du Rocher's apparatus are called upon to render very great services. They will make a genuine revolution in the pathology and therapeutics of the bladder and stomach, and too much attention cannot be directed toward them, nor their inventor be too much congratulated.—*La Nature.*

ELECTRICAL DEPOSITION OF FUMES.

By F. L. BARTLETT, Portland, Me.

IN Mr. Malvern W. Iles' interesting articles on the condensation of fume, he mentions that the use of electricity presents a promising field for success. I had considerable faith in the use of electricity until I had quite thoroughly covered the ground by experiments in a somewhat large way; and I am now doubtful of the utility of electricity for depositing fume of any kind, though possibly my experiments may have been crude and not in accordance with the correct principles for the application of electricity.

Briefly, they were as follows: I first procured a small Holtz machine with plates less than 12 inches in diameter, which was run by a motor connected with a storage battery. The whole affair, being light and portable, proved very convenient in manipulation. A box was prepared about 20 inches in diameter, the bottom covered with a loose copper plate in connection with wires for attachment to the Holtz machine. In the box, suspended by a brass rod, was an insulated plate of dry wood covered with tin-foil, and with the under side filled with brass points, the whole affair made adjustable by sliding brass rods. Fume was let into the box by means of a three inch opening in one end, and allowed to pass out by an opening in the opposite end; and by means of other boxes of larger size attached to the first one, any particles not caught in the first might be saved in the second box. The fume consisted of oxide and sulphide of zinc containing from 16 to 20 per cent. of sulphide of lead, very light and free from all metallic substances and siliceous dust, and was taken at such a distance from the furnaces that it was perfectly cooled. There was no smoke present, but the fume moved in an atmosphere composed principally of sulphurous acid gas and the gaseous products of combustion from the furnaces.

The conditions seemed favorable, and the first application of the electric current from the Holtz machine caused instant collection of the fume into small snowflake-like balls, which were alternately attracted and repelled when the fume was held inclosed in the box, or passed in showers into the outer boxes when the fume was allowed to pass somewhat rapidly through the boxes The experiments were varied, and many other plans tried with the small machine; but no plan gave better results than the one described. One thing was always noted in these experiments: Complete precipitation could not be effected, even though the fume passed ever so slowly through the electrified box; there seemed always to be a portion that would not collect; yet analysis of that portion, easily collected, gave evidence that it differed in no way from the fume when wholly collected by passing through cotton bags. However, the success was deemed sufficient to warrant the trial of a larger machine, or one of sufficient size to work on a commercial scale. Accordingly, I had built a Holtz machine of modified form, containing 8 double plates, 20 inches in diameter, the machine being run by power. This, when charged and run at 400 revolutions a minute, required about 1¼ horse power. It is perhaps needless to say that the amount of electricity generated was something enormous. Sparks received from it were young thunderbolts, and would nearly unjoint one's fingers. It was reasonable to suppose, in the light of the other experiments with the smaller machine, that this large one would give results at least equally good in proportion. First, a ring was made of 2 inch brass tube and covered with ¼ inch copper netting studded with points. This ring was arranged at one end of a room, 60 by 42 feet, into which entered a 30 inch pipe conveying the gases and fumes from a blast furnace. All the fume was made to pass through the electrified ring and thence over a metallic plate in a moderately slow current. When fully charged and in a dry atmosphere, a portion of the fume collected in flakes and slowly deposited on the floor of the room, but in a bulky and exceedingly light condition, so that the merest breath would disintegrate and blow the collected particles away. Various expedients were resorted to, and many schemes were tried, but in no case could more than a fractional part of the fume be collected. The electricity seemed abundant, but nevertheless no results approaching anything like a commercial success were attained. All the experiments were tried under the direction of a skilled and competent electrician. It may be that the gases in the fume, or the composition of the fume itself, or the application of wrong principles, had something to do with our lack of success. Still, the undeniable fact stands out that we were comparatively successful when operating on the fume in closed spaces free from currents. The conclusion that we arrived at was, that the process, while interesting as an *experiment* in a small way, could never be made useful on a large commercial scale. Even granting that the fume can be collected by means of the static current, it would be so bulky and require so much space that it could never compare with the bag process in economy.

A recent letter from Mr. Alfred O. Walker, of the Bagillt Lead Works, England, although expressing hope, does not as yet intimate success in his experiments with electricity as an agent for depositing fume.

OTHER PROCESSES.

After trial of condensing chambers, water sprays, steam jets, and wire netting, I am of the opinion that no process can begin in economy, cleanliness, and dispatch with the "bag process;" and I am also of the opinion that, when properly applied and better understood by smelters, it will leave little to be desired in the way of fume collection. I do not understand that the old fashioned process of blowing fume through cotton or woolen bags, such as is now in use in zinc oxide works, is subject to any patents. The Lewis-Bartlett process is for the collection of special fume for lead paint, and as I have seen it at the Lone Elm Works, at Joplin, Mo., is quite different from the old zinc process. At all events, patents on the bag part would not hold, since it has been too long known, too long used, and too often described. Contrary to general opinion, the plant necessary for cooling and blowing fume through woolen bags is neither very expensive nor complicated; and after it is once in operation, is lasting and easily managed.—*Eng. and Min. Journal.*

SOUND AND COLOR.

IN his article upon the "Music of Colors," Mr. De Brial attributes the phenomenon of colored hearing to a simple association of ideas; but I am going to try to show that certain persons really do have a sensation of a color when they hear a sound, and that it is to this property, which is more or less unconsciously possessed by many persons, that must be attributed the approximations unanimously established between sound and color.

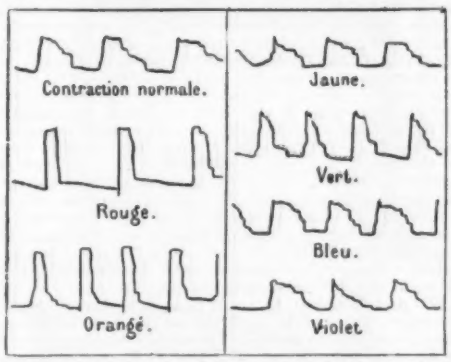


FIG. 1.—CONTRACTIONS OF A PERSON UNDER THE INFLUENCE OF VARIOUS COLORS.

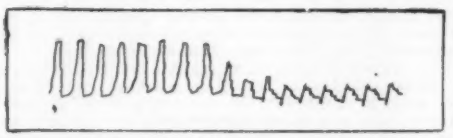


FIG. 2.—MODIFICATION OF A NORMAL CONTRACTION THROUGH THE USE OF RED GLASS.

In the *Revue Philosophique*, and in various reports of the Biological Society, Dr. Charles Féré has given the result of his researches relative to the action of sensorial impressions upon the human organism, and has clearly established the following points: (1) The intensity of the sensation of hearing, and that of the sensation of sight, increases proportionally to the amplitude and intensity of the sonorous or luminous wave; and, consequently, vibration seems capable of being considered as the unit of excitation for hearing and sight.

(2) The excitation of any one of our senses is shown by an appreciable effect on the dynamometer, and may have the result of making another sense enter into action.

It will now be understood how the hearing of a sound may evoke the perception of a color; but, thanks to the kindness of Dr. Féré, I can follow the question still closer and put before the reader's eyes the apparatus that the Doctor has used, as well as an exact reproduction of the tracings that he has obtained, in his studies upon the action of colors. This young and learned physician of the Salpetriere, having found that some of the hysterical patients of the hospital appeared to be differently influenced according to the nature of the luminous ray that met their eyes, endeavored to compare these impressions by using one of their most easily measured manifestations—that is to say, by means of the muscular stress developed by the hand under their influence. To this end, the subject takes in his hand (as shown in Fig. 5) a dynamometer with metallic spring, which, by means of a bent lever and a rod, transmits the stress to a rubber drum filled with air. The pressure of the latter is transmitted, through a rubber tube, to a style which inscribes its oscillations upon a cylinder that revolves around its axis under the action of clockwork. The apparatus having been set in operation, the subject makes a series of contractions with his hand at the order of another person, and these contractions produce curves upon the cylinder that vary in form according to the nature of the light seen. Fig. 1 shows such curves, first under the influence of ordinary light, and then under that of red, orange, yellow, green, blue, and violet. It will be seen that they have a well characterized form for each color, and such form is reproduced not only when the same color is made to act upon the same subject, but also when the same color acts upon the different subjects.

The normal curve closely approximates to the yellow one, this being quite natural, since yellow rays hold a preponderant place in sunlight.

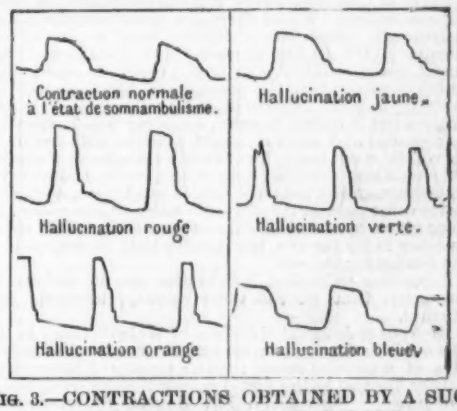


FIG. 3.—CONTRACTIONS OBTAINED BY A SUGGESTION OF IDEAS OF COLORS.

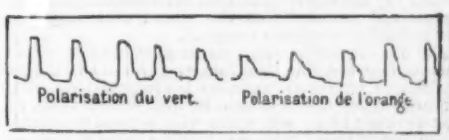


FIG. 4.—POLARIZATION OF GREEN AND ORANGE.

Fig. 2 shows how the normal curve is modified when a red glass is abruptly placed before the subject's eyes.

So, generalizing from that which is demonstrated only for exceptionally sensitive subjects, it might be said that our mind perceived colors in consequence of certain vibratory motions communicated to our entire organism by vibrations of what is called ether. We may go further and say that, if our mind evokes the idea of a color, our entire organism will enter into the vibratory state that corresponds to such color.

In fact, after putting one of his subjects into a somnambulistic state, Dr. Féré suggested to him to see red, orange, yellow, green, etc., and by the process described above obtained the curves reproduced in Fig. 3, where we observe the same characteristic forms as in Fig. 1, but less wavy, because the subject was better isolated from disturbing causes. Fig. 4 shows the transformations of the curves that correspond to the

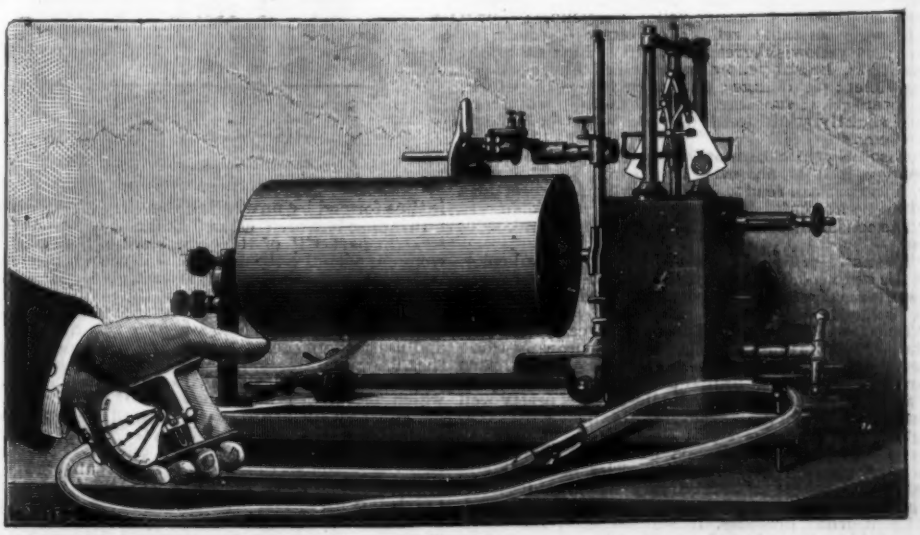


FIG. 5.—COLLIN'S DYNAMOMETER FOR REGISTERING CURVES PRODUCED BY STRESSES OF THE MUSCLES.

perceptions of green and orange in curves corresponding to the complementaries of these colors under the influence of a magnet.

In short, it will be seen that the muscular contractions exerted under the influence of various colors seem to denote in the subject various vibratory states, in which the vibrations differ not only in intensity, but also in form.

Now, we know that in curves traced on a registering apparatus by the vibrating extremities of a sonorous body, it is the *form* of the curve that is the characteristic of the *timbre* or quality. Here is an approximation, which, although not complete, nevertheless deserves being noted, because it is confirmed by other observations.

It will be remembered, in fact, that in the phenomena of colored hearing it is *timbre* that plays the chief role in the seeing of color; and this intimate relation between *timbre* and color is so felt by certain races that the Germans call the former the *color* of *sound* (*Klangfarbe*).

What many people have considered up to the present as only more or less ideal comparisons are in reality the expression of a physical impression. I shall cite a few examples.

In his Esthétique, Mr. Eugene Veran says: "If we employ instruments that give only a fundamental sound, we produce merely dull gray music, which, on the contrary, becomes colored with chords whose vibrations are not interfered with by anything, and which consequently emit a fundamental sound increased by a large number of harmonic sounds."

Mr. Sully Prudhomme, whose authority in such a matter cannot be questioned, is of the same opinion: "In the various sounds emitted by the same vibrating body there exists one essential quality, and the most constant of all, that which persists in all the variations in pitch and intensity that its sonorousness can undergo, and that is the *timbre*. And so it is by its *timbre* (quality of tone) that every musical instrument is especially specified. While there are notes common to all instruments, each has a *timbre* that is exclusively peculiar to it. In like manner, there exists in all visual sensations a quality which is proper to each, and which persists when the quantity of light received by the body and the brightness of its color vary. It is precisely what is called its color, a quality which specifies its essential and most constant relation with the optic nerve. So a red body, for example, remains of the same red shade although the light falling upon it may vary, and although the red may vary in brightness, as when a water color painter dilutes with more or less water the color given by the same cake of vermilion. This specific color is for the eye the quality that corresponds to the *timbre* for the ear."

According to Berlioz, it is by the use of various instruments that we can color melody, harmony, and rhythm.

Meyerbeer designated certain of Weber's tunes in the *Chasse de Lutzow* as purple, and Mr. Eugene Fromentin says of a piece of music: "The palette of Rubens resounds therein in the few dominant notes, red, black, and gray." Conversely, Mr. Eugene Sylvestre thus analyzes Eugene Delacroix's painting representing the Shipwreck of Don Juan: "Delacroix pursues the immensity of the heavens and sea between blue and green, makes red resound like the sound of trumpets, and draws dull moans from purple."

Are not all these artists, all these writers, sensitive to various degrees, like that former pupil of the Polytechnic School who thus describes his impressions and the circumstances under which he first noted them? "I was working in a study room with several companions, when one of them, who was talking in an undertone to his neighbor, raised his voice, and, addressing all of us, asked, 'Is not *a* red?' Without leaving my work, I answered, 'Evidently, for to me the sound *a* is red.' At this answer all our companions burst into loud laughter, for none of them understood it. The result was a great discussion; and, a conference being held, we were submitted to this experiment: We were successively shown objects of various colors, and asked what in our opinion was the corresponding sound. As a general thing, our answers differed but slightly, yet were never identical. For example, I remember a book whose cover was of a light green, a little soiled by use; and I gave for the corresponding syllable *bœil*, while my companion gave, I believe, *meil*. These two sounds are not the same, but they nevertheless resemble one another. One of the differences between our impressions was due to the fact that to me the sound *é* is dull yellow, verging upon gray, while my companion found it pearly gray.

"I have endeavored to define either the color that I perceive for the simplest sounds or, conversely, the sounds that I think of when I see a colored object, and I have reached the following result: *a*, red; *á*, garnet; *é*, grayish yellow; *è*, orange-yellow; *e*, yellow; *i*, brilliant, with metallic reflex; *o*, blue; *ô*, smalt; *u*, violet; *eu*, yellowish green; *ou*, dirty-blue; *ai*, bright currant; *ei*, bright yellow; *oi*, celestial blue; *ui*, dazzling violet; *aé*, orange; *ia*, red mixed with white; *ieu*, pearl-gray; *iu*, clear white; *dî*, dull white; *îd*, white slightly translucent, like the white of a hard-boiled egg.

"Absolute white cannot be expressed by a sound; moreover, it does not exist in nature. In like manner, no sound can render black, of which the best idea is given by absolute silence.

"The consonants modify tones, and, in general, sully them.

"The nasal sound *n* implies the idea of a dead color, and the sound *b* indicates a faded one—so, old dusty papers have a color that may be expressed by the sound *beu*, *bun*.

"The sound of large bells, and of a cannon in the distance, and the low notes of a piano are brown verging more or less upon red; the noise of a cannon heard near by is brown with brilliant dots.

"Sunlight during a pure cloudless sky is pretty well represented by the perfect accord obtained with silver or glass balls that give a very clear sound. The reflection of the moon upon the sea in calm weather gives the idea of sharp notes like a series of sweet and harmonious whistlings, and, if my memory does not deceive me, this effect has been used in an opera.

"From what precedes, it will be seen that, as a general thing, the color of an object is represented by quite a complex sound, and it is as difficult to render, by a very appropriate sound, the color which we see as it is to find upon a palette the colors which render the effect that we desire to reproduce."

The comparison is a very just one, and the exceptional sensitiveness with which our correspondent is endowed will explain to the reader what has been told to me of a distinguished Parisian painter. This artist usually carries with him in his excursions merely a pencil and some paper, and in order to recall colors is satisfied to recite vowels and diphthongs at the proper places upon his sketches; so that one can truly say of him that he paints with sounds.—*A. De Rochas, in La Nature.*

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MacCord, Sc.D.

I.

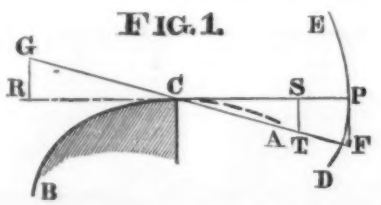
In the construction of mechanical movements, it often occurs that while a perfect action would require a certain point to traverse a part of some peculiar curve, yet this path may be so short, and its variation in curvature so slight, that a circular arc will give an approximation close enough for practical purposes. In these cases the object may be accomplished, and the mechanism simplified, by the use of a "radius rod" or "bridle rod," of which one end is pivoted to the moving point and the other end turns about a fixed center. Obviously, it is practically important that under such circumstances the length of the rod and the location of the center shall be correctly determined. On the other hand, regarding the investigation of the properties of any curved line from an abstract point of view, it is self-evident that for the mathematical student, a clear understanding of the questions relating to the tangent, the normal, and the radius of curvature is essential to the completeness of his knowledge. Nor does it matter, so far as the actual utility of this knowledge is concerned, how such an understanding is acquired. These problems are to be found fully discussed in various treatises on mathematics, but by methods beyond the attainments of many who are interested in the practical bearings of the subject, and of many also to whom the study is in its very nature attractive, without reference to utilitarian considerations. In relation to the radius of curvature in particular, it will not, we think, be going too far to say that to determine it in the usual manner requires a degree of familiarity with the calculus which, for the great majority, is difficult to acquire, and still more so to retain. Aside from this, and without questioning the advantages of analysis in respect to generality and minute precision, it is also true that the connection between the equations and the lines is to most minds obscure, the aid of a diagram being requisite to a complete realization of the mutual relations between the various elements of the problem.

We now propose to show that it is not in all cases necessary to resort to analysis for the solution of these questions; and to explain a method—which we believe to be new—of determining the radii of curvature of many plane curves by very simple graphic constructions. The exercise of due care in the execution will insure a degree of accuracy ample for all practical purposes, such as those above alluded to; while if more minute precision be desired, the results may be verified by computation, since the processes are geometrically correct and the demonstrations rigid.

The proposed mode of operation is based upon the fundamental ideas of regarding a line as generated by the motion of a point, the tangent as the direction of that motion at a given instant, and the normal as a line also in motion. These are concrete ideas; others, with more leisure, may wrestle with the hair-splitting (or side-splitting) arguments that a point cannot move because it *is* nothing, but merely indicates a position in space, and that a line is also immovable for reasons equally valid—and vapid; our purpose is served by the conception of a material particle which is capable of moving and of marking out for itself a path in space, as a circle is traced by the point of the compasses. And a clear, physical idea of the matter under consideration may be formed by imagining a very thin, inextensible, perfectly flexible wire or steel tape, first to be wound upon the convex edge of a curved ruler, thus coinciding with its surface, and then to be kept straight and taut while being unwound. The free end will then describe a curve, to which the extended wire is normal, and the length of the straight part is the radius of curvature.

We thus form the conception of two intimately related curves lying in the same plane; the one which is unwound is called an *evolute*, and the one traced in the unwinding, an *involute*. In Fig. 1, the curve DPE

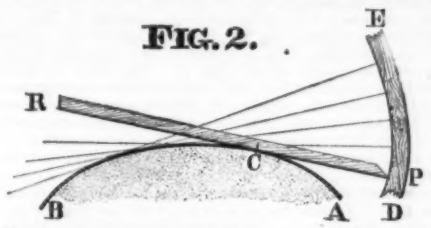
FIG. 1.



is thus formed by unwinding the curve AB; when the unwinding has been carried as far as the point C, the straight part CP of the wire, having the point C in common with the curve ACB, and yet not intersecting it, is tangent to the evolute at that point. It is, moreover, normal to the involute at the point P, as above stated; because, the wire being inextensible, the motion of P can have no component in the direction CP, and must, therefore, at the instant, be perpendicular to that line; and the same holds true for every point between P and C. It evidently makes no difference in which direction P moves now. If it go downward, as indicated by the arrow, the wire will be wrapped up again upon CA, and P will retrace the curve PD. Supposing it to move downward, then, it is to be noted that the action at the instant is not affected by the presence or absence of the part CA of the evolute; CB being fixed, every point in CP is free to move downward, except the terminal point C, which is immovable. This being the case, and the wire being inextensible, the condition that it shall remain *straight* requires that the velocity of every point in it shall be proportional to its distance from C; in other words, the wire turns about C like a lever about its fulcrum. Since PC is by supposition straight, it may be extended as shown by the dotted line CR; and if we now regard PR as a rigid instead of a flexible wire, and imagine it to *roll* upon the fixed curve AB, the action will be precisely the same as before, the point P tracing the involute curve, and the wire being always tangent to the evolute.

From this it will be seen that if the straight edge shown in Fig. 2 be forcibly moved so that the point P

FIG. 2.



shall traverse the curve DE, while at the same time the face PR is always normal to that line, any plastic material occupying the space below the ruler will be swept into the form of the curve AB, the evolute of DE. We may thus regard the two curves as simultaneously formed by the motion of one straight line; and, as shown in Fig. 1, this motion at any instant is simply one of rotation about a point C, lying upon the line itself, and also upon the evolute.

The graphic process, then, of finding the radius of curvature of any given curve at any point, consists of two steps, viz.: the drawing of a normal at that point, and the determination of this center of rotation. It is not necessary that the evolute should be drawn, but it is often desirable, both on account of its relation to the involute, and as serving to check the accuracy of the work; and it is mapped out with great precision by drawing a series of normals to the given curve.

Proceeding now to the consideration of these steps in detail, the drawing of the normal to the given curve depends upon first drawing the tangent, to which it is perpendicular; and this again, regarding the line as generated by the motion of a point, means determining the direction of that motion at the instant when the point occupies a given position. This determination may in most cases be made graphically, when the law of the motion is given, by employing the method of Roberval; a method which, on account of its elegance, simplicity, and directness, deserves to be far more widely known than it is. As applied to plane curves, it involves only the most elementary propositions relating to the laws of motion, viz.:

1. If a material point receive a single impulse, the motion thereby imparted may be represented in direction by a straight line, and in velocity by a definite portion thereof.

2. If it receive simultaneously two impulses, the motion due to each may be represented by the adjacent sides of a parallelogram; and the resultant, or actual motion of the point, will be represented by the diagonal passing through their intersection.

A few examples will best serve to show how these principles are made use of in the drawing of tangents.

The *ellipse* is defined as a curve such that the sum of the distances from any point thereof, to two fixed points, shall be constant. Hence, the well-known method of tracing it by means of a pencil, P, Fig. 3,

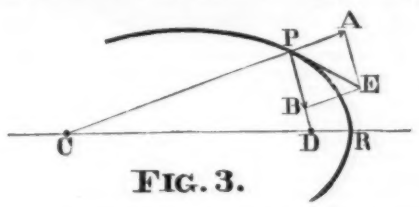
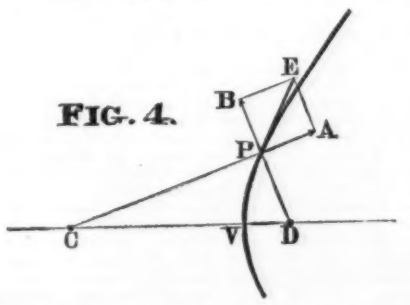


FIG. 3.

moved so as to keep always taut a string fastened at the two fixed points C D. Since the total length of the string is invariable, whatever is added to the segment PC must be subtracted from PD; in other words, P approaches D just as rapidly as it recedes from C. Then if we prolong CP to A, and set off toward D the distance PB=PA, these two lines will be the component motions, and completing the parallelogram, PE is the resultant motion and tangent to the curve at P.

In the *hyperbola*, Fig. 4, the *difference* of the two

FIG. 4.



distances PC, PD is constant, so that P either approaches, or recedes from, both C and D at the same rate. In the figure the latter is the case, and PA, PB are accordingly equal prolongations of CP and DP.

The *parabola* is defined as a curve every point of which is equally distant from a given straight line and a given point. Supposing it then to be traced by a moving point, that point must approach or recede from both the focus and the directrix at the same rate. Then in Fig. 5 make PA, on the prolongation of FP, equal to PB drawn at right angles to the directrix LL, and PE, the diagonal of the completed parallelogram, is tangent to the parabola at P.

The *circle* is described by a point moving subject to the condition that its distance from a given fixed point shall be constant; that is to say, it can neither

approach nor recede from this center. In this instance the application of Roberval's method is slightly modified; the motion of the generating point can have no component in the direction of the radius, and its direction must, therefore, be perpendicular to that line.

A like modification applies to the point at which the ellipse cuts the major axis; thus R, in Fig. 3, approaches D just as rapidly as it recedes from C, so that these two component motions neutralize each other; the actual motion of the generating point must, there-

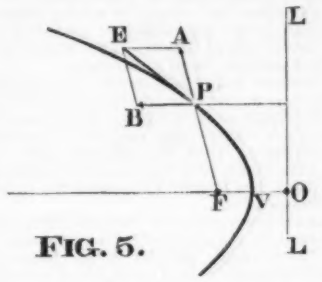


FIG. 5.

fore, be perpendicular to CD. Similarly, at the vertex of the hyperbola or the parabola the components in the line of the axis are equal and opposite, and the motion is perpendicular to that line.

A single example will show that the same reasoning may be used in respect to curves of double curvature. The *helix* is a path traced on the surface of a cylinder, as the resultant of two component motions; the first would carry the generating point around a circumference of the cylinder, while the second would in the same time carry it through a definite distance along an element, both motions being uniform. If, then, through the generating point we draw a tangent to the circle, and also a line parallel to the axis, and set off upon these lines distances proportional respectively to the circumference and to the pitch, the diagonal of the parallelogram of which these distances are the sides will be tangent to the helix.

Now, this may not be absolutely pure mathematics, but it certainly is unadulterated common sense; the physical ideas involved are as simple as the geometrical principles applied to them, and while Roberval's method is not applicable in all cases, yet, as we shall see, many quite complex curves may, by the exercise of a little ingenuity, be made amenable to the same mild treatment. And when it can be employed, this process is not only peculiarly adapted to our ultimate purpose, but remarkable for the direct and clear exhibition of the reason for every step.

HINGED AND BALANCED LAMP-POST.

THE accompanying illustrations, which have been selected as typical examples from a number of patterns ready for issue, represent an improved form of lamp-post designed by Mr. Alfred Kitt, Engineer of the Lupus Street (Pimlico) works of the Gaslight and Coke Company. The principle of the improvement is sufficiently explained by the figures, as it consists simply in hinging the lamp-post upon a pivot placed at a convenient height, so that, when the safety catch is unlocked, the lantern may be brought down as required within reach of a man standing on the pavement for lighting, cleaning, painting, or repairs. The great saving of time and labor thus insured, and the advantage of being able to dispense with the ladder, are sufficient to recommend Mr. Kitt's plan in substitution for the ordinary lamp-posts. For pillars, however, intended to carry the large and improved lanterns now so generally preferred, the advantages of the new system are much greater. Special manipulation and care in cleaning and repairs are required for these large lanterns, since a man cannot get round them from one position of the ladder. By lowering them to the ground, however, everything can be done without

HINGED AND BALANCED LAMP-POST.

removing the lantern from the post, and in very much less time. If preferred, the gas may be lighted by torch in the usual way, or the lantern may be hung in a sling for lighting from the ground, as shown in one of the illustrated patterns. The hinged portion of the post is counterbalanced, either as a lever or by a weight hanging inside the base, and only a small key is required to secure the joint.—*Jour. of Gas Lighting.*

CYLINDER BOX-NAILING MACHINE.

AMONG the many interesting and ingenious labor-saving machines to be seen in the Inventions Exhibition last year was the cylinder box-nailing machine of

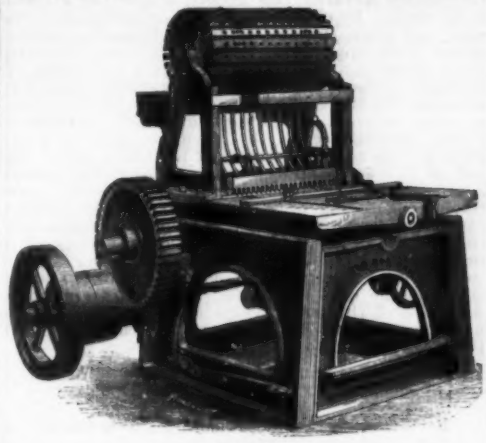


FIG. 1

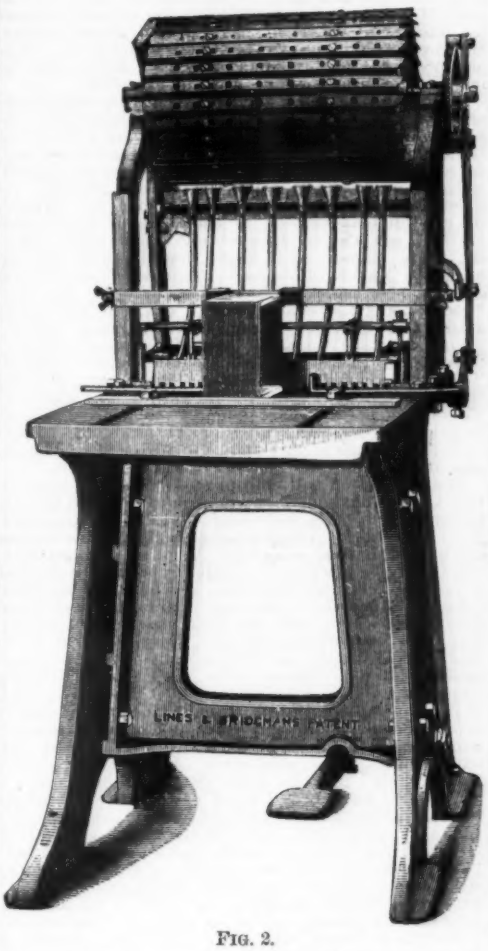


FIG. 2.

FIG. 3.

CYLINDER BOX-NAILING MACHINE.

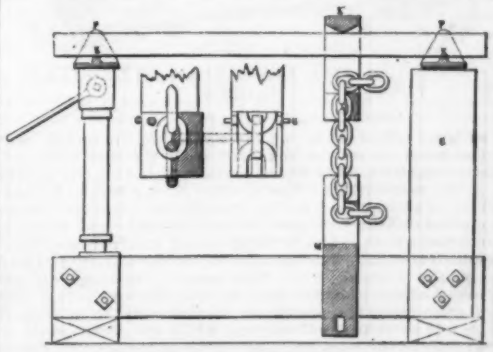
Messrs. Lines & Bridgman, which was exhibited by Messrs. Mosses & Mitchell, of 68 Chiswell Street, London, and received the highest award. This machine we now illustrate. Fig. 1 represents a machine driven by steam power, and Fig. 2 another for manual power. In this machine the wood is placed on a table, and the nails forced into it by movable pushers acting upon the nails. The inventors arrange the nail guides so that all nails may be driven in square, or in such directions that those on each side of the center nail point either inward or outward, the center nail guide being at right angles to the surface of the wood. The nails are fed to the nail guides in the following manner: A horizontal cylinder is formed with series of holes arranged in rows extending across from end to end. An attendant supplies the holes with nails, which are placed with their heads downward. In a line with each row of holes is a sliding perforated bar, the perforations of which, when in one position, are coincident with the corresponding row of holes in the cylinder, so as to permit the nails to be fed to the holes. After the nails have been fed, the attendant pushes the sliding perforated bar endwise, so as to cause the solid parts to cover its corresponding row of holes in the cylinder. This sliding of the perforated bar is done in order to show which rows of holes the attendant has fed, and thereby to prevent feeding more than one nail to each hole for each revolution of the cylinder. In the rotation of the cylinder the sliding bars pass a fixed cam which, in the event of the attendant having omitted to slide any of the bars, will automatically cause the sliding of them, so as to insure all the holes being covered before they come to the lower part of the cylinder.

In order to release the nails from the holes as they arrive over the funnels connected by tubes to the nail guides, the sliding covering bars are, by means of a sliding cam acting upon a lever, moved endwise until the holes therein again coincide with the holes in the cylinder, thereby permitting the nails to fall into the funnels. The nail guides are formed of a bottom grooved plate, which is adjustable, both as to height and inclination, in respect to the table of the machine, in order to adjust the parts to different thicknesses of wood, and to the angles at which it is required to drive the nails into the wood, while by such means nails with either large or small heads can be used, as by tilting the plate a large-headed nail can be presented to the wood in a direction either parallel or slightly inclined to its face. Over this grooved plate is a series of guides, to which the tubes are fixed. These guides below their junction with the tubes are open at their undersides to permit of the falling of the nails into the grooves of the bottom guide plate, and they are also formed with openings for the passage of the nail pushers, while along the front of the nail guides is a guard plate, which, when the nail pushers are in their restracted position, stands with its toothed edge resting in the grooves of the bottom guide plate and thereby prevents the nails from falling or jumping out of their guide grooves, and their remains until the pushers begin to advance, at which time it is automatically lifted, after which the plate is again lowered on the retirement of the pushers. Although from our description this machine may to some appear to be a little complex, it really is not so, as our illustrations show, while in action it is very simple, and it can, moreover, be adjusted to any kind of work, as we have witnessed. Any kind of nail can be used—brads, cut-clasp, rose-head, clout, French or tanter hook nails, from one to three inches long, and the machine will drive from one to eleven nails at each impression. The machine can be worked by either women, girls, or boys, the simplicity of the parts requiring neither technical knowledge nor practical experience. It is claimed that the cases made by these machines are superior in finish to those made by hand, being perfectly square and true in every way; the nails are evenly driven and regular throughout, and the heads always slightly below the surface of the wood. The saving effected by the substitution of this simple and rapid mode of nailing for hand labor is very great. It is stated that a woman and a girl with one machine will produce from 1,100 to 1,200 boxes per day, but that with a set of machines to follow up the operations consecutively, and so avoid loss of time in altering or readjusting, some 5,000 boxes can be turned out in the same time. It is calculated that each machine will perform the work of eight men. Fig. 3 of our engravings represents a very useful adjunct to the nailing machine. This is a perforating machine for the lids and backs of hinged boxes, and by means of which it is stated a girl can perforate from 5,000 to 6,000 lids and backs per day. This is of course done before the boxes are nailed together, and as the wood is perforated from the same gauge, every lid must fit each box perfectly. Being interchangeable, the boxes can be hinged at a considerably less cost than is ordinarily paid.—*Iron.*

MACHINE FOR TESTING CHAINS.

IT is of the greatest interest for the many persons who use chains to know from time to time what confidence they can place in them, and also to have a means of testing them upon delivery after purchase.

After an earnest study of the manufacture of cast steel chains, Mr. Imbert has been led to devise a test-



MACHINE FOR TESTING CHAINS.

ing machine, which he has just presented to the Society of Mineral Industry. His design has been to get up a very powerful apparatus, which at the same time should be simple and inexpensive. This problem has been solved by him, with the aid of Mr. A. Barbier, as follows:

In the first place, the selection of the hydraulic jack appeared to him to be indicated by reason of the very

extended and efficient use that he had recently made of it at Terrenoire in some laboratory experiments in which strong pressures were necessary. But the very arrangement of the jack was ill adapted to such an application, and it would have been necessary to construct at great expense a cumbersome and not very secure metallic frame in order to obtain direct traction, and also to purchase a jack of great power and of high price. He was therefore led to devise the arrangement shown in the annexed cut.

A strong oaken column, C, of 12×12 in. section, is firmly fixed by a tenon to two oaken horizontal pieces, which are connected at one end by the said tenon, and at the other by a piece of oak whose upper surface is flush with that of the horizontal beams, and which supports the jack, V. The column, C, is of the same height as the jack, and its head and that of the latter carry two identical pieces of cast iron, F, that form guides, and are provided with knife edges, K, cast in a piece with them. Upon these knife edges rest the extremities of a bar of Bessemer steel that has a section of 1¼×6 inches, and traverses a collar, M, of cast steel. The upper part of this latter is provided with a knife edge, K', and the lower with a nut whose depressions are filled by three successive half-links of the chain to be tested. The structure of this piece may be seen from an examination of the figures in detail. An analogous collar keyed under the frame completes the whole. A strong bolt, G, traverses each collar parallel with the plane of one of the rings, in order to prevent slipping.

Owing to the peculiar arrangement of these two collars, a chain of any length whatever may be tested by a number of links limited only by the distance between the steel beam and the frame. By fixing the lower end of the chain in a ditch beneath the frame, a chain several yards in length might be tested; but such lengths are inconvenient, and it is better to make the test with small successive fractions.

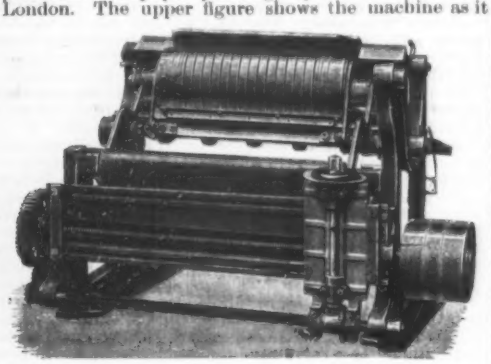
The apparatus that is in operation at Mr. Imbert's works is provided with an 8-ton jack. Upon placing the upper collar at any point whatever upon the beam, we obtain stresses proportionate to the length of the arms of the lever. It is thus that with an 8-ton jack we can test a chain to 24, 32, and 40 tons.

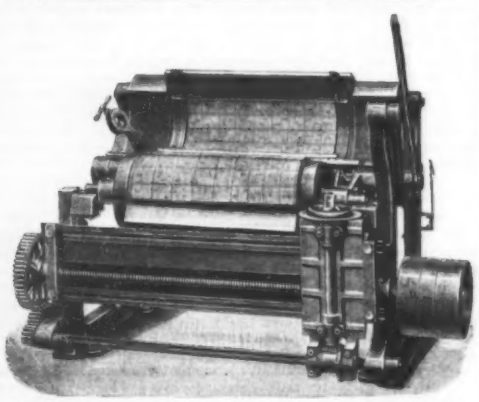
A high pressure manometer screwed into the side of the jack shows at every instant the stress that is being exerted upon the chain under experiment.

It will be seen that such an apparatus costs but quite a small amount. The estimate for an apparatus to test chains of ¾ in. links is $79: *i. e.*, $40 for an 8-ton jack; $8 for the wood; $18 for the iron and steel; and $13 for the pressure gauge.—*Revue Industrielle.*

STEREOTYPE MACHINE.

WE illustrate a machine for preparing stereotype plates for newspaper printing, by Albert Sauvée, of London. The upper figure shows the machine as it





MACHINE FOR PREPARING STEREOTYPE PLATES.

appears when all is ready for running the metal, and the lower shows the box open with the core removed, carrying with it the stereo plate, and leaving the matrix in the casting box. The flexible papier mache impression of the type set up by the compositors is laid in the curved casting box, and the cylindrical core, which is carried by two arms, is then moved into its place, leaving an annular space between it and the matrix, and into this the metal is run. This space is bounded on the lower edge and at the ends by the sides of the box, but is open along the upper side for the metal to be poured in. It therefore follows that while the stereo plate is exactly of the required dimensions on three of the edges, the fourth carries a runner or git which must be cut off to bring that side to the proper form. To effect this the core is moved out of the box, and as the plate embraces more than half the circumference of the core, it is carried with it, and is placed with its runner near to a circular cutter mounted on a vertical shaft fixed in a sliding frame. When the belt is moved on to one of the fast pulleys, the cutter is set in motion by means clearly shown in both views, and at the same time the saddle in which it is carried is drawn along the front of the machine by the leading screw. By this means the superfluous portion of the plate is removed. To prevent the teeth of the cutter being damaged by coming in contact with the core, there is formed in the latter a groove at the place where the cut is to be made. During the casting operation this groove is filled by a metal strip carried by two arms pivoted eccentrically to the core; and when the core is moved from the position shown in the upper figure to that in the lower, this strip sinks deeper into the groove and leaves a clearance for the teeth of the cutter, which can penetrate completely through the stereo plate without hurt either to themselves or the core. The rotary cutter can be carried in either direction across the machine, and as it approaches the end of its travel, the saddle moves the belt on to the loose pulley, and thus stops the motion. All the arrangements have been specially devised to save time in the casting of the plates, and we understand, says *Engineering*, that when the men are accustomed to the working of this casting box, the time occupied in preparing the papier mache matrix, putting it in the casting box, and getting the plates out ready to put on the machine does not exceed from 6 to 6½ minutes. As time is of the utmost value in the bringing out of a newspaper, we have no doubt this new casting box will prove very useful to newspaper proprietors.

GLUCOSE.*

By WILLIAM H. BREWER, Ph.D., New Haven.

GLUCOSE is the name given by the chemist Dumas to grape and starch sugar. With chemists, the name is applied to a kind of sugar which is found ready formed by natural processes in the juice of grapes, plums, cherries, figs, and many other sweetly acid fruits. It is also produced in the animal kingdom, and it may be made by art from certain organic compounds.

Popularly, it is the common name for the sugar made artificially from starch, and which comes into commerce both in a solid and liquid state, and under a variety of trade names. In the technical journals and in statistical reports, the solid forms of starch sugar are usually called "grape sugar," and the term "glucose" restricted to the liquid and semi-liquid varieties. This is the general classification in the German and French journals, but the varieties are sold under many different trade names, each large manufacturer having brands or names of his own. Thus we have "mixing glucose," "mixing sirup," "corn sirup," "jelly glucose," "confectioners' crystal glucose," etc., for the liquid grades and "grape sugar," "solid grape sugar," "clipped grape sugar," "granulated grape sugar," "powdered grape sugar," "confectioners' sugar," "brewers' grape sugar," "maize sugar," etc., etc., for the solid kinds, but the public call it all "*glucose.*" These various brands are made by essentially the same chemical process, and whether the product is liquid or solid depends in part upon the degree of conversion and in part upon the amount of water left in it.

The production and consumption of starch sugar in this country have increased enormously within the last ten or twelve years, and along with the increase of use have come many charges against its wholesomeness when used in food or drink. Very sensational statements have been widely circulated in the newspapers as to its alleged unwholesomeness, and much public alarm created. Moreover, it has been extensively used as an adulterant, where such use is unquestionably fraudulent; this has perhaps increased the widespread belief that it is an actual and serious danger to the public health, and many States have passed laws specially aimed at it. This State has enacted that "No person shall knowingly, willfully, or maliciously sell or offer or expose for sale within this State any sugar or molasses which has been adulterated with . . . glucose, dextrose, starch sugar, corn sirup, or other preparation from starch." (Public Acts, 1880, chapter lxxxiv., p. 543.) But I have never heard of any effort to enforce this law, although it is probable that three-fourths of the table sirups used in the State are so adulterated. Michigan has a less sweeping but equally strict law: "No person shall mix any glucose or grape sugar with sirup, honey, or sugar intended for human food . . . without distinctly marking, stamping, or labeling the package containing the same with the true and appropriate name of such article, and the percentage in which glucose or grape sugar . . has entered into its composition." (Laws of Michigan relating to Public Health, 213, Act 254, Laws of 1881, Sec. 4.)

In Germany, where glucose has long been an article of manufacture, chiefly from potatoes, and where it is used extensively in brewing, several chemists have published investigations showing that when it is fermented, unwholesome products are found in the fermented product. Other investigators have denied this, but the uncertainty gave grounds for uneasiness in this country when the manufacture was so rapidly growing and the subject brought so widely and frequently before the public mind without any authority as to what the real sanitary relations of artificial glucose was, and this renewed public interest has led to a fuller investigation of the whole subject than has heretofore been made.

The five years from 1878 to 1882 inclusive marked the greatest expansion of this manufacture, and in April, 1882, when perhaps forty thousand bushels of corn daily were being converted into glucose, and when a bill was before Congress "to tax and regulate the manufacture and sale of glucose" (H. R., 3,170), the Commissioner of Internal Revenue asked the National Academy of Sciences to investigate and report on its "saccharine quality as compared with cane sugar and molasses, and also especially as to its deleterious effects when used as an article of food or drink, or as a constituent element of such article."

The matter was accordingly put into the hands of a special committee, consisting of Professors Geo. F. Barker (Chairman), Wm. H. Brewer, Charles F. Chandler, Wolcott Gibbs, and Ira Remsen. As bearing on the sanitary value of their conclusions, I may say that all are chemists, four of them specially eminent authorities in that profession, four have been prominently connected with other sanitary investigations, and two have had long experience as officials on boards of health.

This commission was in existence more than a year and a half; the members examined in person some manufactories and were in communication with very nearly all which then existed in the country; they bought such samples in the markets as they could get, and sent a special agent through the manufactories of the Western States, who examined the processes and collected samples which were afterward analyzed by or under the direction of the commission. Some other samples were furnished by the Commissioner of Internal Revenue. There is an enormous literature relating to the chemistry and the technique of the subject, which was carefully looked up and collated, and this bibliography forms a part of their report. The material itself was made the subject of a long investigation as to its manufacture, chemical and physical properties, and its physiological action. The report of the commission has recently been published.

As the present paper is intended for popular reading rather than as a scientific treatise, and as there is much popular misapprehension on the whole matter of its relation to other sugars, the majority of people in this country thinking that the manufacture is new and that the experience with the product is limited, I think it fitting that the matter be considered historically as well as chemically.

The sugars are a group of chemical compounds which are produced by chemical or vital processes in nature, and are found ready formed in the juices of various plants and animals, mixed with other substances. All the sugar used in the world, except that which we are now more especially considering, is, chemically speaking, a natural product. The various processes of sugar-making are processes for separating it from other substances with which it is mixed in nature, but where it already exists chemically formed.

Chemists have described many sugars having similar but not identical chemical composition and differing in their sweetness, chemical properties, texture, and other physical characters. They are included in a class of compounds known as *hydrocarbons*, containing the three elements hydrogen, carbon, and oxygen. These hydrocarbons are divided into three groups, two groups of which are sugars: 1. The cane sugar group, or *sucroses*, to which group belong the sugars from cane, beets, maple, also the sugar from milk and others less popularly known. 2. The grape sugar group, or *glucoses*, to which belong the sweetening principle of grapes, figs, plums, honey, and various other sweets. 3. The starch group, or *amyloses*, which are not actual sugars, but which includes starch, gum dextrine, cellulose, etc., etc., some of which substances may be artificially converted into sugars of the glucose group by chemical processes. We may say that as a whole the *sucroses* or true sugars crystallize easily, that the *glucoses* crystallize with difficulty or not at all, and the *amyloses* not at all. In the presence of ferments, the most of the sugars undergo fermentation, and a considerable variety of products result, depending on the kind of sugar, the kind of ferment, and the conditions under which the fermentation takes place. The *glucoses* are directly susceptible of vinous fermentation without previous change, but the *sucroses* must be converted first into glucose before this fermentation takes place. It is easy to artificially convert several of the *sucroses* and *amyloses* into glucose, but difficult or impossible to reverse the process in the laboratory. In nature and by vital processes, however, this change takes place on a grand scale.

Sugar in some form has in these latter years become such an important article of human food that we forget how modern such common use is. We no longer consider it a luxury, but rather a necessity, a food which in the ordinary American family ranks along with flour in its cost and daily use. But this abundance is very modern, and even a knowledge of sugar has not long been common. So far as we know, honey was the only sweet known to the ancients. Sugar, as such, only appears in literature after the Christian era, and Europeans obtained their first practical knowledge of it in the dark ages, along with the Mahometan invasion and the wars of the crusades. The various European names, the authorities tell us, came through the Arabic *Sok-kar* from the older Sanskrit *Sha-kara*, and that the cane came into southern Europe along with the Mahometans. The Moors brought it to Spain, and the Arabians and Saracens to the islands of the Mediterranean; from these, the Portuguese carried it to the Madeira Islands and the Canaries about 1420, and for nearly a century what little sugar was used in Europe came mostly from those islands. The amount produced, however, was very small until the cane was carried to the West Indies from Madeira, in 1506; then the production increased with great rapidity, and for the next three hundred years these islands produced very nearly all the sugar used in the world. But until well in the present century it remained a costly luxury, which was more and more sought after as tea and coffee came into more common use. But sugar was entirely a tropical product (except the local and insignificant supply from the sugar maple) until well into the present century, and it was considered then more of a luxury because it was not produced in the countries which used it in the largest quantities.

As early as 1747, Margraff, a Prussian, found that beets and various other plants of northern and central Europe contained small quantities of sugar, but no means were found of extracting it economically. The extraction of cane sugar from the vegetable juices which contain it in small proportions and along with acids is emphatically a chemical art, and could not be devised until there was a chemical science, therefore all the early efforts to produce it on a commercial scale from other source than the cane (from which it was easily extracted) were failures.

Chemistry may be said to have had its birth as a science with the discovery of oxygen in 1774–75 and the consequent establishment of the modern theory of combustion. The new science grew rapidly, but it was still many years before we had a good chemical theory on which chemical analyses could be founded on a scientific basis or chemical experiments be intelligently directed toward definite ends. But even before this came about, and so soon as chemistry began to be a science, this costly and coveted luxury began to be investigated by the aid and methods of this new science.

In 1790 Tuchten extracted a sugar from honey which Lowitz showed in 1792 to differ from that derived from the cane. In 1797 Achard devised a process of extracting sugar from beets, which his old teacher, Margraff, had shown existed there fifty years before, but the process was not economically successful. In 1806 Provost

* From the Seventh Annual Report of the Connecticut State Board of Health.

described the sugar in grapes, and between that date and 1810 Bouillon, Dombasle, Lagrange, Montalivet, Parmentier, Vauquelin, and Vogel experimented and wrote on the subject of extracting sugar from grapes, and the name "grape sugar" became a familiar term in common speech. Deyeux demonstrated the difference between grape and cane sugar in 1810, and by this time it came to be pretty well known by chemists that nature produced various sugars differing in chemical composition and physical characters, and some having much greater sweetening power than others. The high prices of sugar, and its constantly increasing use, along with the growing use of tea and coffee, furnished a stimulus to these investigations, aside from their scientific value. Hence, the numerous processes devised about that time for the production of sweets from European sources.

The next year, 1811, Gotlieb Siegismund Kirschoff, a Russian chemist, discovered that sugar was produced by the action of dilute acid with moderate heat on starch. This discovery was published to the world in 1812, and before the close of that year other chemists experimented on the subject and several papers were published pertaining to it in the various European scientific journals.

This was indeed a great discovery. Heretofore sugar had only been known as the direct product of life, a compound chemically produced only by physiological processes; but here was sugar as a purely laboratory product. What had before been made only by nature was now made by man, independently of climate or country, for starch could be produced from a great number of species of cultivated plants, the product of nearly every variety of soil and climate.

The time of this discovery was especially opportune, for owing to the Napoleonic wars and the incident blockade of the Continental seaports, sugar had risen in price until in some towns it was sold for a dollar per pound. The new sugar was supposed to be "real sugar" (or as we now say "*cane*" sugar), and it was hoped and believed that chemistry had made the grandest contribution to the comfort of man which the youthful science had yet done.

Under the stimulus of the high prices and great scarcity of sugar which then prevailed many manufactories came into existence, and soon immense quantities of starch sugar were produced, and the cultivation of potatoes in Germany, which until then had gained but slow headway for food, rapidly and greatly increased as a source of starch from which to make the new sugar.

All this, remember, took place more than seventy years ago. Thus early was extensive glucose production established.

But chemists very soon discovered that the new sugar was not identical with cane sugar in composition or properties, and its consumers likewise soon found out that it had much less sweetening power and was not nearly so well adapted to certain uses in the kitchen and in the arts, and was for many uses inferior to the "real" sugar.

Then came important political events which changed all the economical factors in the problem. The downfall of Napoleon in 1814, the peace and treaties of 1815, the blockade of the Continental ports ceased, cane sugar from the colonies in the West Indies, where it had accumulated and become cheap, again poured into the newly opened ports, there was a great fall in prices, and the manufacture of the inferior starch sugar rapidly declined.

Great efforts were made to find a market for it, especially for brewing and for increasing the strength and quantity of wine; nevertheless, from a variety of causes, its manufacture continued to decline, and for a time it practically ceased to be an industry of any importance. Its production did not, however, absolutely cease. Some demand for it continued, chiefly for brewing and for confections, the manufacture revived again and slowly increased, and has continued down to the present time. It is an industry so well and so long established that it will doubtless continue to be one of great commercial and economic importance.

On the Continent starch sugar is made almost entirely from potato starch, and French and German sorts from that source have long continued to be imported into this country for confectioners' uses. Much "candy" contains no other sugar whatever, and for some cause the certain foreign kinds continue to be preferred by confectioners to any of American manufacture.

The process of making starch sugar in this country, where maize is the raw material used, is essentially as follows: The starch is first separated from the corn, as in ordinary starch manufacture, by soaking, grinding, straining, washing, and final settling on long "tables" or shallow troughs. In making commercial starch it is dried after this washing and settling; but if glucose is to be made the starch is not dried, but at this stage is run with water into large vessels, where it is converted into sugar by the action of very dilute sulphuric acid along with moderate heat. The chemical action or "conversion" is carried further in making the solid "grape sugar" than in making the liquid "glucose." The length of time and degree of heat are somewhat different in the different establishments, and are also regulated according to the use to which the product is ultimately to be applied.

The acid is then neutralized with chalk or pulverized marble, the resulting sulphate of lime is separated, the liquid solution is clarified, concentrated in vacuum pans, and is decolorized by bone black, just as cane sugar is.

The commercial product is a mixture, in varying proportions, of two sugars, called respectively *dextrose* and *maltose*, and of *dextrine* (starch gum), with very variable quantities of water, the liquid forms naturally containing the most water. Some of the solid "grape" sugars are as white as the finest "loaf" sugar, others (used chiefly in brewing) are yellowish. The taste varies also very considerably. Some of the liquid varieties are as colorless and limpid as water, even when so thick that they will scarcely flow, others are honey-colored or faintly yellowish, and others amber, the colors passing through every shade of amber and brown to that of dark sugar-house molasses. The colors are under the control of the manufacturer, and are ultimately related to the uses for which the special kind is made. The greatest variety is in the liquid forms or "glucose," and the prejudices of ultimate customers are humored, who associate some particular color with their table sirups, and want their "pure sugar-house sirup," "honey drip," or "maple table sirup, warranted pure," of the orthodox color.

How early the manufacture of starch sugar was attempted in this country, I do not know; but while a chemical student, in 1849, I examined a table sirup then being manufactured from corn in a New England city, and I have had verbal accounts of several earlier attempts. There were many later, but these sporadic trials were probably unsuccessful as business ventures until a dozen years ago or less, at any rate, the amount of sirup or sugar produced from that source in this country was very insignificant.

In 1864 two patents were issued by our patent office for improved processes for making sugar from starch, since which date a large number have been issued, but it was not until about ten years ago that the manufacture assumed any considerable importance. Before 1875 or 1876 comparatively little starch sugar was made in the country, and then, particularly between 1878 and 1882 the production suddenly assumed immense proportions.

Previous to 1880 I have no statistics of production in this country. Census Bulletin No. 304 (1880) gives seven glucose factories, with a capital of about two and a quarter millions of dollars and a gross value of product of over four and a half millions of dollars. Professor Wiley states that Aug. 1, 1880, there were ten glucose factories in the United States, consuming about 20,000 bushels of corn daily, and I think it probable that some five or six millions of bushels of corn were converted into starch sugar that year and ten or twelve millions of bushels in 1881. Various estimates have been given of the production in 1882, few placing it below twelve millions and some as high as fifteen millions of bushels of corn consumed. The Academy Commission reported thirty-two factories in 1883, with an aggregated capital of at least five millions of dollars, and the average consumption of corn was estimated to be at least 40,000 or 45,000 bushels daily, although the amount fell off during the last half of that year, and was probably smaller rather than larger in 1884. It must be remembered that the production is a very fluctuating one. The commission was able to get a probably complete list of the starch sugar manufactories in the country, but it was found impossible to learn precisely what the real magnitude of the business was, and the above amounts are but estimates which were more probably below the mark than above it. They are sufficient, however, to give some idea of the enormous amount of starch sugar made here.

Regarding the production in Europe, statistics are very incomplete and are not continuous, but there are figures enough to show that the production is enormous. In 1855, Payen, in the third edition of his *Chimie Industrielle*, placed the French production of starch sugar (from potatoes) at 5,500 tons per annum. There are many German figures scattered through various publications which show a large production there. Wagner, in his *Chemischen Technologie*, states that in 1874 there were sixty glucose factories in the German Empire, with an annual production of 360,000 centners (19,800 tons of 2,000 pounds as we reckon) of sirup and 500,000 centners (27,500 tons) of solid sugar. Post, in his *Chemischen Technologie*, places the production of 45 factories in Germany, during the fiscal year 1877–78, at 5,931 tons sirup and 8,135 tons of solid sugar. Wagner's *Jahresbericht der Chemischen Technologie* for 1877 states that 2,221 tons of starch sugar were used in the manufacture of beer in Germany in the previous year, and in the volume for 1882 he gives in his statistical tables the product of the two preceding fiscal years in the German Customs Union as follows: for 1880–81, 11,768 tons "grape sugar" (solid) and 17,970 tons "glucose" (liquid); and for the fiscal year 1881–82, 18,384 tons "grape sugar" and 18,782 tons "glucose."

These figures are sufficient to show both that the industry is a large one and a very fluctuating one.

This fluctuation in quantity made is partly due to great fluctuations in the demand, in part to the relative prices of barley (for malting) and of corn (or potatoes) from which to make starch sugar, in part to other causes. In this country the manufacture is always associated with that of starch, the two going on together more economically than that of glucose alone could, and when for any cause the demand for glucose falls off, the establishment can be used for the production of starch.

What use is made of all this immense production? We rarely see it offered for sale as such in the markets; now, what becomes of it?

Starch sugar is used for nearly all the purposes for which cane sugar is. It is a constituent of much, if not the most, of the table sirups now used in the United States; it is extensively used in confectionery; it is used as an adulterant of cane sugar (but not to so great an extent as is often stated in the newspapers); it is used as a substitute for cane sugar in canning fruits and the manufacture of fruit jellies; it is used to adulterate honey, and even sold as strained honey; and so on of numerous uses where a sweetening substance is wanted. In many of these cases the use is perfectly honest and legitimate, in many others an unmitigated fraud.

In all of the above uses the grape sugar is used directly as an ingredient of food and taken into the stomach as sugar, but its largest use is for fermentation. As already stated, the *glucoses* undergo vinous fermentation directly, and its most extensive use is in brewing, where it is used along with malt as a cheaper substitute. Some is also used to doctor wines, and some also is fermented into vinegar.

The amount used in the arts for uses not related to foods or drinks is so comparatively insignificant that it need not be considered, and we may say that practically the whole of the immense production goes ultimately into the human stomach, either in food or drink; therefore, the importance of its sanitary aspects is universally conceded. Is starch sugar, or, as the public calls it, *glucose*, specially unwholesome, either when taken directly into the stomach with food or when fermented as an ingredient of some drink?

No one supposes that the grape sugar produced naturally in fruits is unwholesome; no one says that these are dangerous to the public health. Moreover, inasmuch as cane sugar as well as starch is converted into grape sugar (*dextrose*) by the action of dilute acids and heat, it follows that grape sugar must often be formed artificially in the processes of cookery by the same chemical reaction that converts starch into glucose in the manufactories. Furthermore, it is the grape sugar naturally produced that undergoes the vinous fermentation in the production of wine and cider, and some other fermented drinks, and of vinegar and other articles of table use against which no charges are ever brought of special unwholesomeness because they are made in part from natural glucose. If therefore commercial starch sugar is unwholesome the deleterious properties must be due to one of three causes, viz.: either the plant from which the starch is obtained also originates some injurious organic compound which is not removed in the manufacture; or secondly, unwholesome materials incident to the manufacture are left in the commercial product; or thirdly, when fermented, specially injurious compounds are formed in the fermentation.

Regarding the first cause, we need have no apprehension in this country, maize being the only material thus far used for the production of starch sugar on any considerable scale. Regarding the other two, the Academy Commission made extensive and it seems to me thoroughly convincing investigations. Many starch sugars were collected and analyses made in duplicate by different chemists working in laboratories widely distant from each other, neither knowing of the work of the others nor of the name or brand or origin of the specimen under examination. In the nineteen samples analyzed, the product of eight manufactories, fourteen contained less than one-half of one per cent. inorganic material, and this residue consisted almost entirely of the same materials that are found in the ashes of plants, *i. e.*, compounds of chlorine, lime, magnesia, and the alkalies. Neither tin nor copper nor other metallic impurities were found in any of the samples which came into their hands. These were the more carefully looked for because of sensational statements that had recently gone the rounds of the press imputing these impurities to "glucose."

In Germany, where large quantities of potato starch sugar are used by brewers, experiments have been published which indicated that injurious substances (other than alcohol) were found in the products of fermentation. There is a conflicting literature relating to this, but no experiments relating to fermented maize starch sugar had been published, so whether or not the public health was endangered by this possible source of injury was in doubt.

This was therefore made the subject of a careful investigation by Professor Remsen, of the committee. He was fortunate in securing assistants who were especially expert and skilled in fermentation work, and also in the place where such experiments could be conducted under specially good conditions. An extensive series of fermentation experiments was carried on for some months and on a considerable scale. The concentrated extracts of the fermentation products were taken in large quantities by several persons without any evidence of unwholesome effects of any kind.

The commission unanimously came to the conclusion that the starch sugar produced in this country from maize is of great purity; that it does not contain injurious substances; that though having at best only about three-fifths the sweetening power of cane sugar, yet it is not inferior to cane sugar in wholesomeness; that the manufacture of starch sugar is a long established industry, scientifically valuable and commercially important; and that they find "no evidence that maize starch sugar, either in its normal condition or fermented, has any deleterious effect on the system, even when taken in large quantities."

That its use as an adulterant is often fraudulent—a fraud on the pocket—there is no question, but it seems to me equally well proved that its use is no special danger to the public health.

A NEW LAW OF THERMO-CHEMISTRY.

By GEORGE F. BECKER.

IN the course of an unpublished chemical investigation of a process involving nearly a hundred reactions, I adopted, as a guide to experiment and as a check upon the conclusions, M. Berthelot's famous thermochemical law,* with extremely satisfactory results.

This law, the experimental proof of which is very convincing, applies only to the final molecular configuration of given substances, however, and gives no information as to the series of transformations which they undergo before reaching a condition of stable chemical equilibrium. But in many of the chemical processes of nature, and in some technical operations, the reactions are interrupted before the final result is attained. In all cases it is a matter of great scientific interest to know the law governing the actual series of transformations, from the initial to the final condition of a mixture of substance, between which reaction takes place.

In the course of the experiments referred to, it appeared to me that the *rate* at which chemical energy is converted into heat by various possible reactions was an important factor in determining the order of their occurrence. But even the determination of the total thermal effects of reactions requires extremely delicate experimentation, elaborate apparatus, and other special facilities. To determine experimentally the rate at which this heat is produced would be a still more serious matter, and was quite out of the question with the time and resources at my disposal for this purpose. I therefore undertook to inquire whether, by considering chemical energy as a form of motion, any definite results could be reached as to the rate of evolution of heat. This investigation eventually led to a principle embracing that sought. It appears under the title of a theorem of maximum dissipativity in the preceding article. The chemical interpretation of this principle is as follows: The sum of the chemical and physical transformations in any chemically active system will be such as to convert higher forms of energy into heat, light, etc., at the greatest possible rate, provided that the interval of time for which the comparison is made is a multiple of a certain fraction of the period of the most rapidly moving particles of the system. For all experimental and for most theoretical purposes this is equivalent to the statement that the transformations will be such as to evolve heat, light, etc., at the highest possible rate.

This law evidently includes M. Berthelot's, of which the principle of maximum dissipativity affords a rigid

* Principe du travail maximum.—Tout changement chimique accompli sans intervention d'une énergie étrangère tend vers la production du corps ou du système de corps qui dégage le plus de chaleur.—Mécanique Chim., vol. i., p. xxix.

demonstration. The tendency to the conservation of molecular type which M. Berthelot has observed in complex transformations * also seems a natural though not rigidly demonstrated consequence, for it can hardly be doubted that a simple substitution in an existing compound will, as a rule, take place more rapidly than a fundamental rearrangement of atoms.

I shall have occasion hereafter to call attention to instances in which, as nearly as can be ascertained without exact determinations of rate, the order of ordinary laboratory reactions conforms to the law here announced. I desire, however, to point out without delay its applicability to a problem of geological chemistry in which exact and direct experimentation is almost or quite impossible, viz. : the order of the genetic succession of minerals in massive rocks. This is a subject of the greatest importance to rock classification and to the whole science of lithology. It is also one in which little or no advance has been made.

No *a priori* guess could be more natural than that the order of succession of minerals in eruptive rocks is that of their fusibility. Indeed, this corresponds closely to the old empirical (and incorrect) rule of chemistry, according to which precipitation takes place whenever an insoluble compound would result from any rearrangement of molecules. Nothing is more easily confuted, however, than this hypothesis of genetic succession, if rigidly interpreted, since magnetite, for instance, is among the first and among the last minerals to form in several eruptive rocks. Bunsen, too, has shown that the temperature at which an isolated body solidifies is never that at which it separates in the solid state from its solutions.† This fact does not appear to me to show that the order of succession has no connection with the fusibility, as is sometimes stated,‡ but only that if such a connection exists, it is not an entirely simple one. There are coincidences between the order of succession and the order of fusibility of the mineral species composing massive rocks which it is scarcely possible to regard as accidental. Thus, zircon and olivine are among the first minerals to solidify, and their only common characteristic appears to be a high degree of infusibility. The highly refractory quartz, too, is an early mineral in the quartzose porphyries, and sometimes, also, in granite. Messrs. Fouqué and Michel-Lévy were, I believe, the first to show § that in the following triclinic feldspar series, anorthite, labradorite, oligoclase, the crystals of primary consolidation almost always precede the crystals of secondary consolidation. They have also shown ‖ that this is the order of the fusibility of these minerals, while Professor Szabo finds that bytownite and andesine occupy a position in the scale of fusibility similar to that which they occupy in the scheme of chemical composition.

The hypothesis that the order of genetic succession is that of increasing acidity has been advocated, I believe, only for granitic rocks. Even for these it is not rigidly true. The order in which the feldspars appear in volcanic rocks, however, is also one of increasing acidity, as well as of increasing fusibility. Such relations between chemical composition and fusibility are of course extremely frequent, especially among organic compounds. Messrs. Fouqué and Michel-Lévy also found albite more fusible than labradorite and less so than anorthite. Those who regard the plagioclases as isomorphous mixtures of anorthite and albite must, therefore, consider oligoclase as the most fusible mixture of the two, while it also appears to be commonly the last feldspar to crystallize. A similar maximum fusibility is known to exist in other series. Thus, the fundamental slag of iron blast furnace practice is an exact bisilicate of the form $4CaSiO_3 + AlSi_4O_9$. This is the most fusible compound of these ingredients, any alteration in the acidity or in the ratio of the bases rendering it more difficult of fusion. Oligoclase contains more aluminum than the slag, but also sodium.

It thus appears that while the chemical composition and the fusibility of the rock-forming minerals are most intimately connected, neither of these properties affords an adequate explanation of the order of genetic succession, nor does any known combination of them explain the facts. That the fusibility at least is not without effect upon the order of succession seems highly probable, but, if so, there are other concomitant influences which very materially modify the results.

If the changes which occur in cooling eruptive magmas obey the laws of thermo-chemistry, the somewhat confused relations actually observed between genetic succession, fusibility, and acidity are just such as might be expected in advance. There is every theoretical and experimental reason to suppose that the fluid eruptive magma consists of one or more compounds differing essentially from the minerals eventually formed from it. In cooling, it must therefore undergo a series of chemical and physical changes. The formation of any new stable chemical compound, whether fluid or solid, in the mass converts other forms of energy into heat; but, at the same time, the subtraction of any such group of molecules from the previously existing combination alters the chemical constitution of the residue. It is quite conceivable that the change in the residue should involve either an absorption or a liberation of heat, but if the former, and if this were to exceed the positive thermal effect of the supposed stable compound, the whole operation would be impossible. In general, if no physical change accompanies the alteration of chemical configuration, that chemical change and that only will take place through which heat is liberated most rapidly.

It is not sufficient, however, to consider the chemical transformations by themselves, for these are in general accompanied by physical alterations in the mass. Much the most important of these is solidification, which is always accompanied by a liberation of heat.¶

Now, the amount of heat evolved by the solidification of compounds is of the same order as the thermal effect of chemical combination. Since, therefore, the sum of the chemical and physical changes must be such as to develop the maximum amount of heat per second, let us say, the fact that heat is liberated by solidification establishes a distinct tendency to the formation of solid precipitates; but this tendency is only operative on condition that by no other transformation can heat be more rapidly liberated.

In view of these considerations, it seems almost certain that the order of genetic succession of minerals will sometimes follow the order of separate solidification, but that in a greater or smaller proportion of cases there will be essential differences between the two orders. Thus, there is no difficulty in understanding that at a certain early stage in the cooling of an eruptive mass, the rapidity of the evolution of heat may be promoted by a separation of a portion of the iron as magnetite, while the separation of the entire mass of this mineral at this stage would be incompatible with the most rapid possible evolution of heat by the entire simultaneous chemical and physical changes then progressing. So also if two magmas of similar qualitative but different quantitative compositions are compared, it does not seem remarkable from a thermo-chemical standpoint that augite should separate before labradorite in the one and labradorite before augite in the other (andesite and basalt).

In one sense the above discussion is of little value to lithology. The new law of thermo-chemistry does not enable one to state what will be the order of genetic succession of minerals under a given set of chemical and physical conditions. This is because the total thermal effect of many of the rock-forming minerals is unknown, while, so far as I am aware, the rate at which reactions evolve heat has not yet been studied by exact methods. But the law at least explains why neither fusibility nor basicity obtains complete control of the process, and how it may happen that the order of succession which prevails in one set of cases may be reversed in another. The new principle governs the genetic succession of minerals in eruptive rocks, but the constants of the equation in which it may be expressed remain to be determined. The number of these constants will doubtless be diminished by future generalizations, and the application to lithology thereby simplified.

Since the rate at which heat is evolved in a solidifying lava is the greatest possible, the rate at which it cools, other things being equal, must be a minimum. This fact must have an important influence on the flow of eruptive rocks and probably accounts in part for the power which they possess of penetrating the tiniest cracks as dikes.

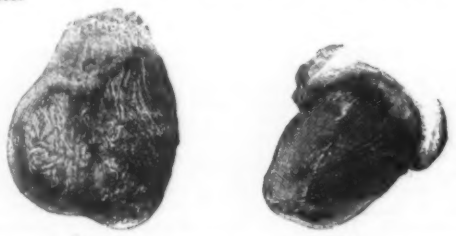
San Francisco Office U. S. Geol. Survey, Nov., 1885.
—*Amer. Jour. Science.*

* Méc. Chim., vol. ii., p. 471.
† Zschr. Geol. Ges., 1861.
‡ Roth, Allgemeine u. chem. Geol., vol. ii., p. 48.
§ Min. microgr.
‖ Comptes Rend., 1878.
¶ Solidification of course takes place at a lower temperature than fusion. This appears to be a theoretical necessity, for if any small fraction of a mass were to solidify at the melting point, the heat evolved by the act of solidification would raise the surrounding temperature above the melting point, and the solid particle would melt again.

INSTANTANEOUS PHOTOGRAPHS OF THE HEART IN MOTION, AND OF PERISTALSIS.

By WILLIAM GILMAN THOMPSON, M.D., New York.

IN so far as I am aware, the application of instantaneous photography to the study of the movements of the heart and intestines has not heretofore been undertaken. For some time I have sought a satisfactory method to measure the degree of alteration in size and form of the living heart between systole and diastole, both normally and under the influence of drugs. The methods I have attempted were: 1. To adapt various forms of linear measures, disks, etc., to the contour of the heart. 2. To incase the beating heart in a chamber of some plastic material which soon hardens and is impervious to serum. The chamber communicates with an upright graduated glass tube, and if the portion of the chamber not occupied by the heart be filled with serum, the latter will be driven into the tube at each pulsation with a force proportionate to the strength of the systole. The volume of serum displaced represents the change in size of the heart. The evident difficulty is to make the plastic material fit tightly about the great vessels of the heart without compressing them too much. Moreover, this method only measures changes of the heart in bulk, not in form, and is so difficult as to be wholly unsatisfactory. 3. To throw a magnified image of the pulsating heart upon a screen by a modified magic-lantern ("panopticon"). A scale marked upon the screen serves to measure changes in size, or a ground-glass screen can be used, upon which the heart can be drawn. Any one who has studied the living heart is convinced of the difficulty of making drawings of it while in motion which are at all accurate.



A B

FIG. 1.—RABBIT'S HEART IN MOTION.
A, full diastole; B, full systole.

Cardiographic tracings are useful, but their showing is limited. Hesse has published * observations upon the changes in form and size of the pulsating heart. He incased it in a plastic material, which moulded itself about the heart, and hardened so as to give a cast of the greatest expansion. The cast could then be bisected, removed, and used itself as a mould to make solid plaster casts. The heart was afterward artificially hardened by chromic acid, and casts were taken of it in its greatest contraction. Obviously, no intermediate stages between full systole and full diastole could be thus obtained, and, moreover, the systole was not a natural one.

The details of the photographic process with which I have recently experimented cannot be cited here. It is sufficient to say that the photographs were taken indoors in November and December, with direct sunlight illumination, and with an instantaneous drop-shutter giving an exposure of about one-sixtieth of a second. To throw the heart into relief from surrounding tissues which are not distinctly colored, I find it convenient to slip behind it a little piece of celluloid. This affords a good white background, and is easily cleansed of blood, etc., by the common spray of physiological salt solution, which is used to keep the heart moist.

I have taken a large number of instantaneous photographs of the hearts of different etherized animals beating *in situ*, and they demonstrate the following points:

1. For students, and those who have not inclination or facility to study the living heart for themselves, they give a clearer conception of its phenomena than any other method.
2. They are more accurate than drawings or casts.
3. The heart is as nearly in a natural condition, both as to systole and diastole, as is possible with an open chest-wall. Artificial respiration may be easily maintained, and, with assistants, kymographic and other observations may be simultaneously recorded.

A B

FIG. 2.—PIGEON'S HEART IN MOTION.
A, full diastole; B, full systole, produced by application of hot salt and water.

4. A series of photographs may be taken between full systole and full diastole which can be compared and studied at leisure.
5. The photographic method shows more than simple linear measurements, for it gives an accurate periphery as well as diameters, and by perspective gives a fair idea of changes in bulk as well as in form.
6. The movements of the heart as a whole, and the forward and upward movement of the apex, which occurs in many animals, are clearly demonstrable.*
7. In addition, the most practical application of the method is the illustration of the changes in the form of the heart produced by drugs. Thus, instantaneous photographs of normal systole and diastole are taken, then an injection of digitaline is given, and the effect of increased force of the systole is photographed and compared with the normal. The effects of doses of varying strength may be thus compared. The contraction produced by dropping a one per cent. solution of glonoin upon the heart shows exceedingly well in a photograph as contrasted with normal systole. I have also obtained photographs of the transverse section of the ventricles in relaxation, and in the contraction that follows thermic stimuli, even after the heart is cut in two. Any experimental work upon the heart while beating *in situ* may be accurately photographed, and many details become apparent when studying the photographs at leisure which are otherwise almost impossible to observe, or quite impossible to record at the time of observation.
8. The negatives, placed in a magic-lantern, show admirably upon a very large scale.

A B C D

FIG. 3.—FROG'S HEART IN MOTION.
A, normal diastole; B, normal systole; C, increased systole produced by hypodermatic injection of digitaline; D, increased systole produced by local application of glonoin, one per cent. (The lower half of each cut is the ventricle, the upper portion is background.)

The series of instantaneous photographs which I have taken of peristaltic movement in the intestines show plainly the effects of progressive degrees of contraction of both longitudinal and circular muscular fibers, and the effects of stimuli—chemical, thermic, mechanical, etc.

Thus, in the elaborate researches of Nothnagel with saline cathartics, he says that certain salts of potassium produce a localized peristaltic wave, while certain salts of sodium produce a wave which travels toward the pylorus. Such facts can be made very real by, for instance, placing a little potassium tartrate upon the surface of a portion of mesentery, and taking a series of photographs of the changes in form and position of

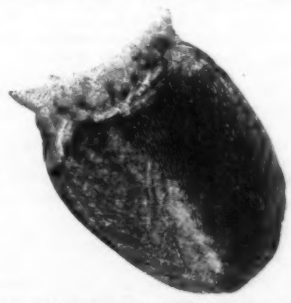


FIG. 4.—CAT'S HEART IN MOTION.
Full systole (viewed from the right side).

* Fr. Hesse: Beitrage zur Mechanik der Herzbewegung; Archiv f. Anat. u. Physiol., S. 388, 1860.

* In the cuts, the background and the varying shadows cast by the moving heart, which make this point clear in the photographs, have been omitted.

the intestine which ensue as soon as the drug is absorbed.

It is difficult to follow accurately with the eye at one time the changes that take place in more than a single loop of intestine, but the camera records the progressive changes occurring in a number of loops, both above and below the one experimented upon.

The application of instantaneous photography may be further extended to the study of the contractions of the stomach, bladder, and diaphragm, and possibly to the study of the movements of the uterus in pregnant animals and the lungs in artificial respiration.

The method is so easy and so accurate that I trust it may prove of permanent value in enlarging our knowledge of the action of drugs upon the cardiac and intestinal viscera, and possibly other organs.—*Medical Record.*

AN IMPROVED APPLIANCE IN PHYSIOLOGICAL TREATMENT OF CLEFT PALATE.*

By HENRY A. BAKER, D.D.S., Lecturer on Oral Deformities, Boston Dental College.

IT has usually been said that lesions of the palate arise from one of two causes, that is, they are either congenital or accidental.

Congenital cleft of the palate was as commonly

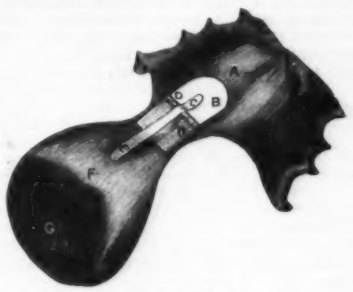


FIG. 1.†

treated surgically as by mechanism. The former treatment has been nearly or quite abandoned in recent years, for two very good reasons: First, it is a very painful one for the patient, and difficult for the operator, and a failure of closure is largely in the majority. Second, it universally fails to improve the speech, even after a successful closure.

Notwithstanding the above facts, some physicians recommend staphyloraphy. They must certainly do so from want of knowledge of the anatomy and physiology of the vocal organs and their use in the mechanism of speech, which is the production of sound, and its direction through the nasal passage or the mouth at will, being controlled by certain organs whose modification and resonance enable us to form what we term articulate speech.

One of the most important aids in producing the above results is the soft palate. This organ is lifted up and comes in close contact with the pharyngeal wall, thus shutting off the nasal passage, which is absolutely essential in producing all excepting nasal sounds. After the operation of staphyloraphy such a closure is impossible, owing to the soft palate having been made too short and tense; hence defective speech invariably follows.

Accidental lesions of the palate, as the name suggests, are caused either by accident or disease. These cases may be successfully treated with a very simple appliance, while the same amount of skill exercised on a congenital cleft would have no beneficial result. This may be accounted for by the fact that in the former case the patient had learned to articulate distinctly, and use the organs of speech efficiently and correctly, while persons who are thus deformed from birth are obliged to learn the art and methods of articulation by slow and painful processes. The organs require the training which is necessary for one who acquires a new language. Hence the appliance for relief should not only fill up the gap in the defective palate, but should

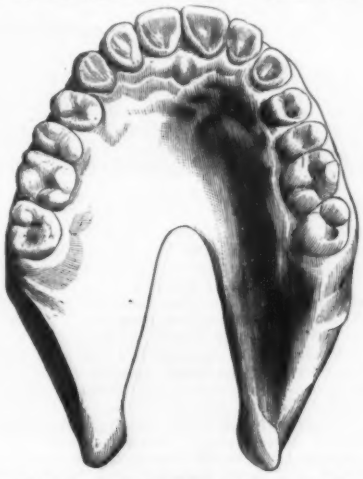


FIG. 2.—The cleft, extending a little beyond the soft into the hard palate.

also be so constructed as to work on physiological principles in harmony with the natural movements; that is to say, it should be under perfect control of the surrounding muscles. It is manifest, therefore, that the success even of the most scientifically adjusted instrument depends largely upon the co-operation of the patient who uses it.

As the above malformations are classed as congenital and accidental, the appliances for their relief are classed as follows: obturators and artificial vela. Among the former Dr. William Suersen is the inventor of one which has created much interest. The most important and significant advance in this department of science, however, made itself manifest in attempts to form an artificial velum, and Dr. Stearns was probably the first to introduce its true principle. I speak of these two investigators, Suersen and Stearns, because I am led to think that they have brought before the profession the most scientific apparatus of each class, and it is from a consideration of both of their appliances that I have evolved the principle in explanation of which this paper has been prepared.

Suersen says: "In order to be able to pronounce all letters distinctly, it is accordingly necessary to separate the cavity of the mouth from the cavity of the nose by means of muscular motion. That separation is, under normal conditions, effected, on the one hand, by the velum palati, which strains itself (consequently by the levator and tensor palati), but, on the other hand, also by a muscle, which to my knowledge has not yet received a sufficient amount of attention in connection with these operations. I mean the constrictor pharyngeus superior. This muscle contracts itself during the utterence of every letter pronounced without a nasal sound, just as the levator palati does. The constrictor muscle contracts the cavum pharyngo-palatum, the pharyngeal wall bulging out, and it is chiefly on the action of this muscle that I base the system of my artificial palates."

It will be noticed that Suersen admits that the levator palati is an important organ of speech, yet he makes no provision for utilizing it as such, and only provides for the superior constrictor muscle coming in contact with the distal surface of his appliance to shut off the nasal passage. In my opinion, for the patient afflicted with congenital cleft to acquire perfect articulation with such an appliance (even if it be possible), years of application and training of this muscle would be necessary. A little reflection will show that this muscle, besides performing its own function, must be trained to fulfill those of the velum palati, levator palati, and tensor palati. But in an *accidental* lesion this may be all that is necessary, as the patient, having previously learned to articulate distinctly, and having this deformity come upon him afterward, the superior constrictor muscle would, no doubt, be sufficiently developed to perform that function.

Sir William Fergusson, in his report of dissection made by him of a cleft palate in 1844, states distinctly that the superior constrictor was very full, and he also claimed for that muscle very decided forward action in

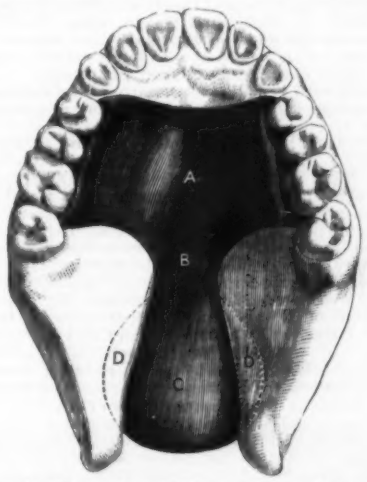


FIG. 3.—Appliance in position: A, the plate: B, the stop, preventing any downward pressure when the muscles are in a relaxed condition; C, the artificial velum; D, D, muscle lying under it, the dotted lines showing the appliance resting on the muscles.

deglutition. It was in the years 1841 and 1842 that Dr. Stearns made his first artificial velum. In 1860 Dr. N. W. Kingsley came into the field, and took up Dr. Stearns' appliance. Finding it too complicated for the general practitioner to construct, and too expensive when completed for those in ordinary circumstances, he was led to serious thought in regard to modifying its production, but he still adhered to the same principle of utilizing the levator muscle.

Dr. Kingsley says respecting Dr. Stearns' appliance: "Two principles were vital to Dr. Stearns' instrument, namely, first, the artificial velum should embrace the levator muscles of the palate, so that it could be lifted by them; and, second, that it should bridge the upper pharynx behind the uvula, and cut off nasal communication at will."

Dr. Kingsley's modification of Stearns' instrument consisted chiefly in leaving off the triple form, and doing away with the central slit, the flap, and the springs. The simplified form consisted of two leaves of soft vulcanized rubber, connected in the median line, the palatal portion running down to the uvula, and then bridging across at that point, and the nasal portion reaching across the pharynx. Instead of the appliance being made in sections so as to slide across each other, as in the Stearns, the bifurcated uvula slides between the two leaves, and the levator muscles of the palate lift it up to meet the pharynx, thus shutting off the nasal passage. It will be noticed that in this simplified form the Stearns principles are fully carried out, and to Dr. Kingsley that credit is due. His claims to originality are in the simplifying of the Stearns instrument.

Dr. Kingsley says: "An important principle enunciated by Dr. Stearns as essential to the success of all artificial vela for congenital cleft was that the instrument filling the fissure in the natural palate must be of the nature of a valve under the control of the muscles surrounding it, and so arranged that it could be elevated by them, thus shutting off the nasal passage, as is absolutely essential in the production of certain sounds belonging to articulate language. This principle was carried out by him first in the character of the material chosen, being of a yielding, elastic nature, and second in the form, being made to embrace the levator muscles, and subject to their control."

Dr. Kingsley in speaking of Suersen's appliance says: "First, that of all obturators this is the best form for a congenital fissure, but while the wearer is enabled to articulate with such an instrument, it is only after he has learned articulation with another apparatus. Second, that a soft, elastic, artificial velum is much better adapted to the acquirement of articulation than any unyielding, non-elastic substance, but when acquired an obturator may be substituted. Third, that in very rare cases articulation may be acquired with an obturator only, but it is the result of the extra activity of the pharyngeal muscles, while with the elastic velum the levators of the palate contribute largely."

A great many practitioners in treating a fissured palate simply separate the nasal and buccal cavities by a thin plate, thinking that the separation is all that is required. Some even make a great parade of this device, claiming it to be an improvement over any other appliance. A little reflection will show this to be impossible, as I shall endeavor to explain before closing this paper.

My own experience with soft vulcanized rubber for an artificial velum is that if it would resist the fluids of

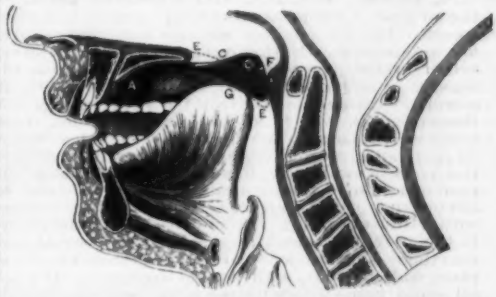


FIG. 4.—The artificial palate thrown up by the muscles, E, E, as in all sounds requiring the closure of the nasal passage; F, the superior constrictor muscle, advanced to meet it; G, the tongue, raised, pressing hard against the appliance, as in pronouncing the letter *k* or *g*; A, the plate; B, the hinge joint and stop.

the mouth, and not go through a process of decay, and change its form, in short, if it could be made permanent, it would be all that could be desired. Since this is impossible, I do not hesitate to say that it is a very objectionable material, and I have been led to long and careful meditation regarding it.

I experimented for five years to provide an artificial appliance with hard rubber, carrying out the Stearns principle, whereby I could utilize the levator muscles to control the movement of the appliance, and with which articulation could be learned as well as with the soft rubber. My studies and experience induced me to settle upon the following device, which consists of a gold or hard-rubber plate (A, Fig. 1), covering the roof of the mouth down to the junction of the hard and soft palates. From this point the artificial velum, F, extends back and downward, restoring the symmetry of the palatal surface by bridging across and lying upon the muscles of each side. The distal surface, G, or that portion coming in contact with the pharyngeal wall, is quite broad, and so constructed as to articulate perfectly with this surface, while the constrictor muscle contracts and closes around it on a semicircle. This is the Suersen principle, and the main ideas I take from that appliance.

The velum is of polished hard rubber, gold, or platinum, and much resembles a chestnut in form.

It is attached to the plate with a hinge joint, B B, thus giving free movement at the junction of the hard and soft palate. At the junction of the hard and soft palate there is a stop, which prevents any downward pressure upon the muscles when in a relaxed condition.

The bulb-like form of the velum (see D, Fig. 4) necessitated a thickness which would naturally have made it quite heavy, and as the resultant weight would be a serious objection, I was desirous of overcoming the difficulty. A suggestion happily came to my relief in this way: While in a drug store I accidentally took up a hard rubber truss made by a Philadelphia firm. Discovering that the pad was made hollow, I thereupon wrote to the manufacturers, asking

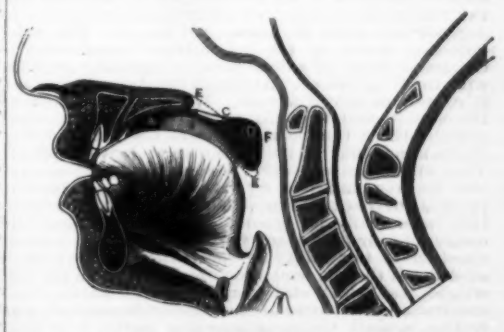


FIG. 5.—The muscles relaxed, the appliance descended, thus giving a free passage for nasal sounds and respiration.

them if they would inform me how they prepared the rubber in that way. In their reply I found that the method was quite simple. It is as follows: Take the vulcanite rubber in the soft state and cut the sheets so that when joined together the desired form is given. Then a little water is dropped into the cavity (I found it better to add a little alcohol), the edges are sealed, and the piece vulcanized in the usual way. The steam produced by the water and alcohol inside creates sufficient pressure to keep the walls distended. By this method, the appliance that the cuts were taken from

* Read by invitation before the Section for Clinical Medicine, Pathology, and Hygiene of the Suffolk District Medical Society.

† The accompanying cuts are kindly loaned by Dr. J. W. White, the editor of the *Dental Cosmos.*

which illustrate this article was made so light that it would not sink when put in water.

In treating a case by Kingsley's method, I was obliged to use a hinge-joint to bridge over a union by staphyloraphy. I found in that case that the appliance was much better controlled by the surrounding muscles, and saw a much more rapid progress in acquiring articulate speech. This led me to more fully provide for that muscular movement, and I will endeavor to give the reasons why this should be done. As we have before quoted from Suersen, in order to pronounce all letters distinctly it is necessary to separate the cavity of the mouth from that of the nose by muscular action, and to close the nasal passage in pronouncing every letter, except *m* and *n*. This can be demonstrated by holding the nose while endeavoring to pronounce all the letters as plainly as possible.

In studying the mechanism of speech, we learn that more than three-fourths of the sounds of articulate language depend upon the integrity of the soft palate for their perfect enunciation. This being the fact, articulation with a rigid obturator must be extremely difficult to acquire. If three-fourths of the sounds depend upon the free movement of the natural palate, it seems to me a sufficient reason why we should provide for that movement in an artificial one.

Dr. Kingsley says that with a yielding appliance the levators of the palate contribute largely to correct speech. The surrounding muscles have control over my appliance in the following way: The artificial velum bridges across the opening and lies upon the muscles of either side. (See Fig. 3, D, D.) With all sounds requiring the closure of the nasal passage it is thrown up (D, Fig. 4) by the levator muscles, there being no resistance. The thickness of the velum brings its posterior surface in close apposition with the superior constrictor muscle, F, and thereby affords, in the pronunciation of the gutturals, a firmer resistance to the pressure of the tongue, G, than can be obtained with a thin obturator. By the presence of the hinge, B, the above movements are rendered so free and easy that there is no tendency to any displacement of the plate, such as occurs with a rigid appliance. If a nasal sound immediately follows a guttural, the descent of the velum is rendered certain by its own weight. (Fig. 5, D.) My first instruments show a spring bridging over the hinge, by which I intended to accelerate the movements of the velum. This I found later to be unnecessary.

To accomplish the above with a material that would be permanent was a problem very difficult of solution. Of course it is impossible to give to a piece of mechanism muscular power, but it should be made so easily movable as to be acted upon by, and be under perfect control of, the muscles surrounding it.

I claim the following advantages for my appliance:

First. That it is made of a permanent material.

Second. That articulation can be learned with it more readily than with any other appliance.

Third. That it is much easier to make.

Thus the unsatisfactory operation of the surgeon has been replaced by artificial organs of precision, working upon physiological principles. The ingenious appliances of our distinguished colleagues, Suersen, Stearns, and Kingsley, whose scientific attainments and researches have reflected such luster upon the art of dental prosthesis, have excited my admiration as I have studied their complex operations; and if I have been enabled to extend their usefulness and increase their value by substituting an imperishable material for the less excellent substances now in general use, I shall consider that the years of study I have given to this remote and rarely considered problem of science have not been altogether without their reward.

BOVINE OR HUMANIZED VIRUS?—A MODEL VACCINE FARM.

By ROBERTS BARTHOLOW, M.D., LL.D., Professor of Materia Medica, General Therapeutics and Hygiene in the Jefferson Medical College of Philadelphia, etc.

THE frequent occurrence of small-pox epidemics is significant of the need of more careful attention to the means of prophylaxis. Jennerian lymph has either degenerated in quality or vaccination is performed in so perfunctory a manner, often, as to be nearly useless. Owing to the sense of security or to the labors of those pestilent humanitarians of the Bergh school, vaccination is also, to a considerable extent, neglected, except in those countries provided with a compulsory law. Although the Jennerian lymph will preserve its original activity, under suitable conditions, it is plain that careless selection of the material for propagation and the utilization of improper subjects have combined to degrade the stock of humanized lymph. The chief objection urged by the opponents of vaccination is the transmission of animal poisons, especially syphilis, with the lymph stock. Although this danger is remote, it cannot be denied to exist. When such observers as Hutchinson and Viennois report examples of vaccinal syphilis, there can be no doubt of the reality of this combination and of its transmission by vaccination. That erysipelas and other contagious maladies may, also, be communicated by vaccine is alleged, but the proof is not so satisfactory. The opponents of vaccination have really no ground of contention than the danger of communicating other infections. The general question of the utility of vaccination has long been settled. If the one remaining objection which has real weight, and which still keeps the Bergh school of humanitarians in countenance, is finally disposed of, protection against variolous infection ought to be fully assured to the human race. The one mode to accomplish this desirable end is to establish the use of bovine or animal virus as the universal practice. This consummation is by no means remote, for Belgium, the German Empire, and very recently Austria, have established bureaus of animal vaccine, and are now issuing that virus exclusively for official purposes under the compulsory vaccination laws. Influenced more especially by the practice and writings of Warlomont, of Brussels, the English sanitary authorities are using the animal virus with increasing frequency. In this country very considerable extension has been given to the production and use of bovine virus.

Unfortunately, there is in this country no official bureau—no central authority—intrusted with the production of animal lymph, and heretofore no establishment for its propagation under scientific control and supervision. This important work is surrendered to private enterprise, and is conducted merely as a business with which the public has no concern, except the purchase of the vaccine matter offered to them. There are numerous "vaccine farms," conducted according to the notions of their respective owners, and well or ill managed as their knowledge permits. In consequence of this state of affairs, there is a general feeling that the medical profession is not yet as well provided with sources of supply as is desirable. The Messrs. Wyeth, of Philadelphia, in deference to the recognized need, have inaugurated an establishment in which all of the scientific skill necessary has been combined with the indispensable business tact and enterprise; for a vaccine propagating establishment which is not at the same time adequately equipped from the scientific side, and successful as a business venture, has no justification for its existence. The vaccine propagating establishment of John Wyeth & Brother is on the estate of "Rokeby," the country seat of the senior partner. This estate is beautifully situated near Westtown, a station on the Westchester Railroad, in Chester County, and about forty miles from Philadelphia. The land is undulating, fertile, well watered, and admirably adapted to grazing and the care of cattle. Fortunately, there are no great herds, and no epidemics among the usual small herds of farmers common to this region. The buildings of the vaccine propagating establishment consist of two stables, an operating and storage house. The stables have each a capacity for forty heifers. Special attention has been given to heating, lighting, and ventilation—to all the elements of a correct hygiene in respect to bovine sanitation. The air space is ample, the windows large, admitting an abundance of light, the stalls roomy enough to permit free motion of the limbs. The temperature is kept uniform by a special heating apparatus, and at the same time the air is freed from excess of moisture and foulness. The walls of the stable and operating rooms are lined with hard wood and the floors are made of asphalt. The drains for the removal of liquid matters are so constructed as to secure immediate results, and the solid excreta are promptly disposed of. The operating room is similarly equipped, and in respect to all the necessary conveniences for carrying on the work of procuring vaccine lymph, is unsurpassed. Skilled assistants are in charge of every part of the work, and the selection and examination of the heifers to be used as vaccinifers, and the direction of the inoculations, are under the immediate management of Dr. Zuill, Professor of Veterinary Medicine in the University of Pennsylvania. The care of the lymph and its preparation for distribution and transport are conducted in the laboratory of the Messrs. Wyeth, where there is every facility for the purpose, especially that kind of facility combined with accuracy of detail which is the chief endowment of an accomplished pharmacist.

The Wyeth vaccine propagating establishment has, thus, a capacity for the production of an immense supply of lymph, and its resources are capable of indefinite extension; consequently, no future epidemics will find the country unprovided with the means of prophylaxis. That the distrust of vaccine lymph which now exists shall no longer be a justification for neglecting vaccination, the Messrs. Wyeth have insured, by procuring for perpetuation, a stock of animal lymph of the highest excellence. Looking over the world's sources of supply, they decided that the vaccine of the Belgium Bureau, originated and propagated under the direction of Dr. Warlomont, and his successor, Dr. E. Janssens, President of the Board of Supervisors of the State Vaccine Bureau and Inspector in Chief of the Hygiene Service of the City of Brussels, is the best now available—that can, indeed, be produced under existing conditions. To obtain this virus and transport it from Belgium, they secured the services of Dr. Sajous, a distinguished physician of Philadelphia, who is, also, the Consul of Belgium in that city. Observing every sanitary precaution, Dr. Sajous successfully transported the lymph, and it is now being propagated at a rate, the only limit of which is the demand. We have thus a vaccine bureau which compares favorably in its appointments and in its product with the best of the official establishments. In some respects a private enterprise of this kind has distinct advantages. As the success of the enterprise as a business venture must be based on the quality of the product, it is obvious that the proprietors must exert their best efforts to maintain the excellence of their establishment. The work of an official bureau, on the other hand, is performed rather perfunctorily, and the officials are not intimately concerned to keep up its reputation.

It is a remarkable fact that, in many instances, persons supposed to be fully protected by repeated insertions of humanized lymph disclose a new susceptibility on inoculation with genuine bovine virus. This result is confirmatory of that view which maintains the decadence of Jennerian lymph, and is a strong argument for the use of the bovine. If there were a final reason necessary to establish the superiority of the bovine lymph, this would, surely, supply it.

While admitting the necessity for a return to the original sources of supply, there are those who deprecate this necessity, because of the trouble which they experience in "getting the virus to take." It has been proved, over and over again, that the bovine virus is as readily inoculated as the humanized, if certain very obvious precautions are taken. As regards the necessity for using fresh and unchanged lymph, the same is true of both kinds. Lymph, the microbes of which have ceased to be active, or that has commenced to decompose, is not only without power, but may be hurtful, by setting up a septicæmia. Bovine, or animal, lymph is more readily obtained now than the humanized, and with the improved methods of storage and transportation there is no part of the world to which it may not be sent in good condition. The chief objection to the bovine lymph has been the apparent uncertainty of its development after inoculation. This uncertainty, experience has shown, is due to the faulty methods of insertion. When quills or ivory or bone points are used, the first step consists in moistening the lymph coating the exterior. Some patience is required for this, and sufficient time must be given to it, until the lymph is soft enough to be entirely wiped off on the scarifications. A little dexterity is required in making proper scarifications. The knife or needle must penetrate to the *reis mucosum* of the derma, and not go beneath the true skin. The layer of cells underlying the epidermis is the true soil for the growth of the virus, and in this must it be planted. Only a little blood should be drawn. It is usual to make a number of transverse scratches, until the soft tissue is reached and a little blood appears; but it is quite possible to reach the necessary depth without inflicting any pain or drawing blood. By carefully scraping off the epidermis over the necessary space, the proper absorbing surface is presently reached, and into this the virus can be rubbed with the certainty of being absorbed, since all of the matter on the quill or ivory point is utilized by being confined to the exposed part of the true skin. Although the scarifications may be made very closely, much of the virus is merely rubbed on the epidermis. To insure success, it cannot be too strongly insisted on that the virus on the quill or ivory point must be softened by water before attempting to rub it in, and that the rubbing in of the virus be done patiently and thoroughly. It is to neglect of these requisites to success that failure is to be attributed.—*N. E. Med. Monthly.*

THE FORMS AND HEIGHTS OF CLOUDS.

ONE of the weak features of contemporaneous meteorology is the almost entire absence of positive and well co-ordinated data in regard to clouds. It may be said that our knowledge concerning this interesting class of phenomena amounts almost to nothing. Aside from a few isolated tentatives, we have limited ourselves up to the present to noting the various varieties of clouds, according to a classification which is twenty-four years old, and which is entirely insufficient, that of Howard. How many researches on the form of clouds, on the height at which they float in the air, and on their nature, can be cited? Very few in truth, and yet the study of these meteors is of an importance that no meteorologist will deny, since, if conducted systematically and rationally, it would cause weather science to take an enormous stride. What would be necessary would be a possibility of submitting the clouds to as complete an observation, or rather to as uninterrupted a one, as we submit the barometer and thermometer nowadays.

Their many aspects should be observed and sketched; their altitude at different times of the day, or under certain peculiar atmospheric conditions, should be measured; while repeated balloon ascensions might make known to us their thickness, composition, and temperature. These are all the questions that obtrude themselves upon modern meteorology, and that it will be necessary for the latter to take up in a near future if it wishes to make progress.

We are happy to be able to make known, in the line of researches just mentioned, an important series of measurements and observations upon the heights and movements of clouds made at Upsal by Messrs. Ekholm and Hagstrom.

These observations were pursued during the summer of 1884, from the 25th of June to the 6th of September. The total number of them was 344, but it became necessary to reject 13 per cent. The varieties of clouds observed were the nimbus, the cumulus, the cumulo-stratus, the alto-cumulus, the cirro-cumulus, and the cirrus, and, on two isolated occasions, the stratus and the strato-cumulus. The observations on the cirro-stratus were not utilized.

THE FORMS OF CLOUDS.

We give herewith illustrations of the principal varieties of clouds.

The *Nimbus* is figured as No. 1 in Fig. 1. It is the

FIG. 1.—FORMS OF CLOUDS.—1. THE NIMBUS.

rain cloud, and has a gray, black, or bluish color and fringed edges. It is generally of very wide extent.

The *Cirrus* (Figs. 2 and 3, No. 2) consists of slender filaments, which, as a whole, have the form of a pencil, crisped hair, a network, the feather of pen, etc. The cirri are the highest of clouds, and consist of particles of ice. Their motion appears to be always a slow one. They are certainly the most important clouds for observation, as they generally announce a coming disturbance of the atmosphere.

The *Cumulus* (No. 4, Fig. 4) often exhibits itself under the form of a hemisphere resting upon a horizontal base. Several of these hemispheres sometimes pile themselves one upon another, and form those great cloud masses in the horizon that from afar off resemble snow-clad mountains. Sailors call cumuli "balls of cotton." On fine, warm, summer days they are frequently seen forming at ten o'clock in the morning, and covering nearly the entire heavens toward three o'clock in the afternoon, and then dispersing in measure as the sun sinks toward the horizon.

The *Stratus* (No. 6, Fig. 4) is a cloudy band limited by horizontal lines. As a general thing, we remark several of these bands (which are parallel and very broad) at the rising and setting of the sun. The stratified form of these clouds is partly due to an effect of perspective. They are lofty, thin mists, which we see edgewise. Owing to their tenuity, we do not distinguish them at the zenith of the place of observation.

The *Cirro-cumulus* (No. 3, Figs. 2, 3, and 4) exhibits

itself more particularly under the form of a small rounded cloud. When a large number of these clouds are seen in the heavens, we say that the latter are fleecy. The cirro-cumulus, as a whole, in fact, looks like a sheep's fleece.

The *Cirro-stratus* (No. 5. Figs. 2 and 4) has the form of a long, narrow, white ribbon. It is often observed crossing the entire heavens from one horizon to the other. The cirro-strati are likewise called "polar bands," and it is supposed that they have some connection with the phenomenon of the auroræ borealeS.

APPARATUS FOR MEASURING THE HEIGHT OF CLOUDS.

The apparatus used by the Swedish meteorologists for measuring the altitude of clouds resembles an astronomical altazimuth; but, instead of a telescope, it is provided with an open tube without lenses, 20 inches in length, and the part of which that corresponds to the objective consists of several crossed brass wires, so as to reduce the action of the wind as much as possible. Instead of an objective, there is a reticule formed of two copper wires at right angles to each other, and 0·02 inch in diameter. The eyepiece consists of a rect-

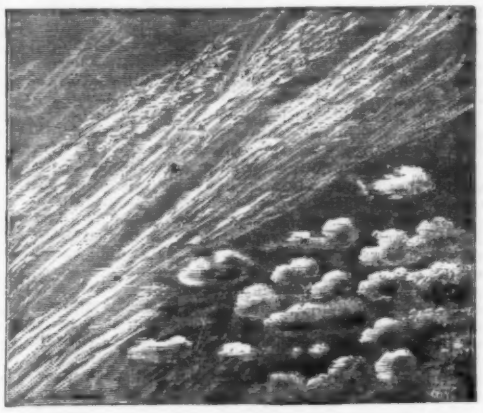


FIG. 3.—FORMS OF CLOUDS.—2. CIRRUS. 3. CIRRO-CUMULUS.

angular plate containing in the center a circular aperture 0·12 in. in diameter. In order that error may be eliminated from the collimation, the plate is movable parallel with the horizontally revolving axle that carries the tube, and, after rectification, is fixed by means of two binding screws. The line of sight, then, is determined by the center of the ocular aperture and by the crossing of the two reticule wires. A colored glass fixed upon the ocular plate, and which can be placed in front of the ocular aperture, or turned to one side, serves to protect the observer's eye when he is looking toward the sun.

The horizontal axis of the apparatus carries the tube at one end, and the circle of heights and a counterpoise at the other—the three forming one with the axis. The distance between the tubes, line of sight and the central point of the apparatus is 7 inches. The trunnions of the axis enter two cylindrical bearings, one of which can be raised or lowered by means of three screws. A spirit level is placed upon the axis near the bearings.

The circle of heights, 9¼ inches in diameter, forms but a portion of the circumference. It is divided into entire degrees from — 7° to 189°. A single vernier, placed opposite the lowest point of the circle, gives the ten minutes directly, but the minutes can be estimated.

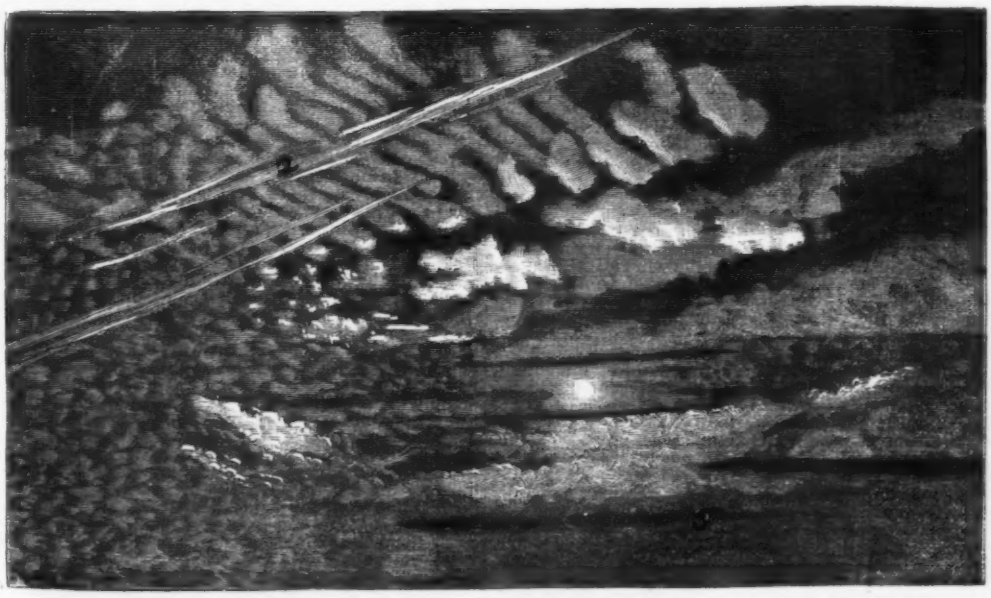


FIG. 2.—FORMS OF CLOUDS.—2. CIRRUS. 3. CIRRO-CUMULUS. 5. CIRRO-STRATUS.

This vernier, as well as the bearings of the axis, is fixed to the vertical axis of the apparatus, whose slightly conical pivot is in the center of the azimuthal circle. This latter, which is 9¼ inches in diameter, and unalterably fixed to the stand of the apparatus, is divided into entire degrees from 0° to 360°, and, by means of a vernier that has been traced upon an alidade fixed to the vertical axis, we read the ten minutes, here also, and by estimation get the minutes. Two clamps permit of fixing the verniers to the corresponding circles, but there is no adjusting screw.

The very solid stand of the apparatus rests, through three leveling screws, upon a pillar, and is about twenty inches in height.

HEIGHTS OF CLOUDS.

All the varieties of clouds may be divided into two groups, that is to say, into upper and lower clouds. The nimbi, cumuli, cumulo-strati, and alto-cumuli belong to the latter category, and the cirri, cirro-cumuli, and cirro-strati to the former.

According to the measurements made by Messrs. Ekholm and Hagstrom, the lower clouds are, as a general thing, found at a height of less than 13,000 feet, and the upper ones above such altitude.

The various strata of clouds are not uniformly distributed in space, but, on the contrary, are arranged by preference at certain altitudes, and are placed, so

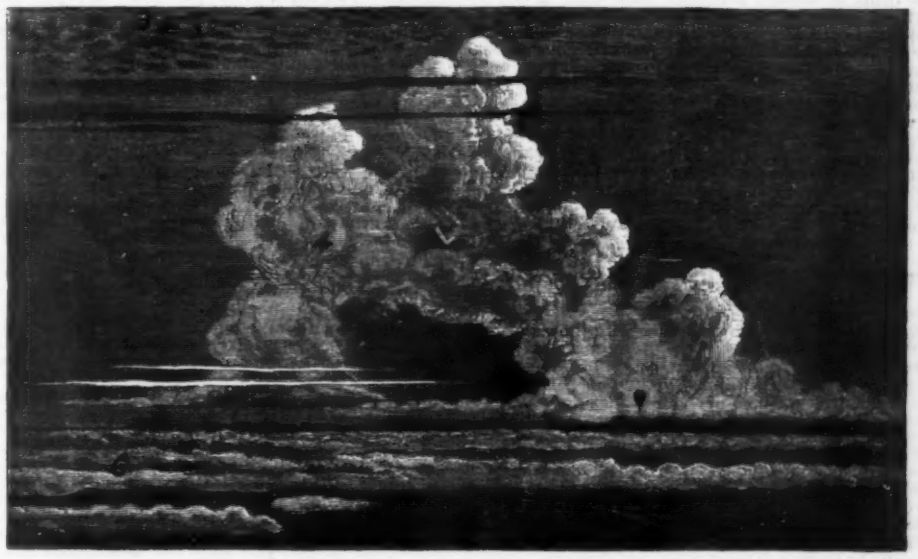


FIG. 4.—FORMS OF CLOUDS.—3. CIRRO-CUMULUS. 4. CUMULUS. 5. CIRRO-STRATUS. 6. STRATUS.

to speak, in tiers one above another. These tiers have approximately the following heights:

1st tier		1,900 ft.
2d "		3,600 "
3d "		4,900 "
4th "		6,560 "
5th "	from 13,775 to	15,000 "
6th "	" 19,000 "	21,600 "
7th "	" 26,200 "	28,200 "

It is self-evident that these heights are merely approximate, because of the too few observations. It may be even possible that there are more than seven tiers.

The first tier is that of the strati; the second, that of the lower nimbi; the third, the mean height of the cumuli; the fourth, that of the lower alto-cumuli; while the fifth, sixth, and seventh correspond to the various strata of high clouds. But with these latter the different tiers do not appear to correspond to so definite varieties of clouds—a fact that it is perhaps necessary to attribute to the small number of observations.

Mr. Vettin, of Berlin, obtained nearly identical results with a different method of observation. According to this scientist, there are five distinct cloud-strata, and the mean heights of these, in feet, are as follows: 1,600, 3,900, 7,400, 13,150, and 23,700.

The mean height of these different strata is not constant, but varies according to the hour of the day, and probably also according to the season, and even according to the general character of the weather, that is to say, according to the distribution of barometric pressure.

A study of the observations has shown the following facts as regards cumuli: (1) The height of the base of these clouds remains sensibly the same during the first hours of the afternoon, and increases during the evening, beginning with the hour at which the cumuli begin to dispense. (2) The height of the summits and the thickness of cumuli exhibit a very pronounced daily variation, whose maximum occurs at one o'clock in the afternoon, and the minimum in the morning and the evening at the hour which the cloud is forming or at that at which it is breaking up. (3) The increase up to the moment of the maximum is more rapid than the decrease up to the moment of the minimum. (4) The height, either of the summits or bases, as well as the thickness of cumuli, varies most along toward the hour of the maximum, and tends to remain constant toward the hour of the minimum in the evening.

The height of nimbi is very variable. The lowest strata seem to be situated at an altitude of but a few hundred yards. When the weather is clearing up, we may observe them reaching a height of 9,800 feet. It seems probable that the nimbi are arranged in nearly continuous strata of several thousand feet thickness, which gradually dissolve in measure as the altitude increases. For want of a sufficient number of observations, it has not been possible to ascertain the daily variation in the height of nimbi. The same is the case with the alto-cumuli, two strata of which may at times be observed that so closely resemble each other as to be confounded, but the height of which, however, is at least 6,500 feet. The strata that keep at an average altitude of 13,700 feet must be considered as formed of relatively low and thick cirro-cumuli.

The stratum of the true alto-cumuli is situated at a very constant average height of 6,500 feet.

The mean height of the cirro-cumuli is 18,000 feet, and that of the cirri 22,000. The latter exhibit a quite pronounced daily variation. Their height continues to increase from eleven o'clock in the morning to six o'clock in the evening.

On grouping the heights of the clouds observed according to the geographical distribution of barometric maxima and minima, Messrs. Ekholm and Hagstrom found that there was not only quite a considerable variation as to height and dimensions in several varieties of clouds, according to the barometric pressure, but also that the average daily variations of which we have above spoken are notably modified thereby. Let us first consider the cumuli. While

FIG. 5.—INSTRUMENT FOR MEASURING CLOUD ALTITUDES.

the altitude of the lowermost portion of these kinds of clouds remains nearly constant, whatever be the barometric pressure, the altitude of the summit, and consequently the thickness, of the cloud shows a very great variation according to such pressure. Cumuli are smallest during a maximum pressure, and increase with a coming depression; but they reach their maximum in stormy weather, and then assume truly gigantic proportions, and may have a thickness of a few miles.

These facts so exactly agree with the theory generally admitted to explain the formation of cumuli that they might all have been deduced therefrom *a priori*. In fact, as these clouds are produced by the ascending

currents that occur in warm weather, and that are very irregular on account of the unstable equilibrium of the sun-heated air, all the causes that tend to strengthen such currents must necessarily increase the dimensions of cumuli and cause their form to vary. Now, the ascending currents that occur under the influence of either great depressions or of secondary and local ones, in stormy weather, are naturally such strengthening causes. The descending currents of barometric maxima must have a contrary effect.

It sometimes happens that the summits of large cumuli rise several thousand feet above the crowns of the false cirri that surround them. Now, cirri, as well known, are composed of small needles of ice floating in the air, while cumuli, on the contrary, are formed of small drops of water. It results, then, that, in stormy weather, masses of air of considerable difference in temperature and moisture may chance to be placed one after another along a nearly vertical surface of several square miles. These enormous masses will then be in a state of very unstable equilibrium, which may, at a given moment, produce an abrupt and violent atmospheric commotion.

The nimbi and alto-cumuli, as well as the higher clouds, do not appear to show variations in height according to the state of the barometer. It results, however, from observations, that the daily variation in cirri is much greater in proximity to a depression than in the center of a barometric maximum.—*Ciel et Terre.*

THE PHOSPHATE MINES OF CANADA.

By BEAU MONT.

THE Ottawa river, the northeastern boundary of the Province of Ontario, and the dividing line between the latter and the Province of Quebec, has long been famous for the rafts of timber floated over its waters from the depths of the forest, and other poets besides Moore have immortalized its beauties in verse. But the days of rafting are henceforth numbered, with the advent of the railway which now pierces the forest solitudes, and the boat song is now heard no more on "Ottawa's tide," or at such long intervals only that, when heard, it seems an echo of the long past. The lumber trade is fast leaving Ottawa city, the old headquarters of the business, and such square timber as is now cut is gradually finding other outlets, and fresh channels of trade than shipment to Great Britain, and the consequent utilization of the Ottawa river as a highway to speed it on its journey.

Skirting the shores of this mighty river runs a vast chain of hills, asuming at times the altitiude of mountains, hills of such antiquity as to be styled by geologists remnants of the earliest land on record. Following, as they do, the course of the river St. Lawrence from the entrance of the gulf of that name to its confluence with the Ottawa, the course of which latter they then pursue, the range of hills has been styled and is generally known as the Laurentian. Rolling in long undulations with rounded rather than rugged or pointed summits, and at just a sufficient distance from the river to allow the ozone of our Canadian skies to tinge them with a blue haze that softens their aspect, they leave a margin of some eight or ten miles, dipping in a gentle slope to the river's edge, rich for agricultural use, and dotted here and there with farms and homesteads and settlements that nestle in the shade of the forest growth, or that stand out in bold relief in the clearing man has made with the sturdy ax. Back beyond that margin bold hills stretch northerly to blue mountains rich in the hoards of provident mother earth; iron, lead, plumbago, and other minerals are there, long hidden from man's knowledge of their value and uses, but which science and the requirements of an improved system of agriculture have now brought to light. This mineral is apatite, or phosphate of lime, and so rich is the quality of that yielded by these Laurentian Hills, and in such demand is it as a fertilizer of the soil after being chemically treated and turned into superphosphate, that an industry has been created in Canada which bids fair ere long to be one of her chief sources of trade, and an important factor in her commercial ranks. Indeed, so rapid has been the growth of this new trade that if the lumber business were to disappear from this district, its void would be filled by that which has sprung up in connection with phosphate.

Unlike other minerials. apatite, or phosphate as we will call it, that being the name it is most commonly known by, is limited in its range, and the phosphate-bearing district is not extensive. Taking the city of Ottawa, the capital of the Dominion of Canada, as a base, a glance at the map will show a section of country north of that point, lying between two large tributaries of the Ottawa river, which flow southward through the Laurentian Hills, the barriers of which form a bar to anything like continued navigation, but which afford the most picturesque effects in their rapids, cascades and falls—tributaries themselves rivers of some 300 miles in length, named respectively the Gatineau and the Lievre. This section, with a belt of four or five miles in width east and west of each of these rivers, is the true phosphate country; beyond this the mineral is apparently wanting, and here it is where mining is carried on to a vast extent and with most profitable results. The townships in which the phosphate most abounds are Templeton, Wakefield, Bowman, Derry, Portland, and Buckingham, and the only place containing anything of a population to entitle it to be called a village is Buckingham, near the mouth of the river Lievre. The Montreal and Ottawa division of the Canadian Pacific Railway passes along the river front of these townships, and a small junction railway connects Buckingham village with the station of that name on the main line, distant east from Ottawa some 21 miles. Although this place has gone through one mining experience, very rich plumbago mines having been worked near it a few years ago, and which, till abandoned, put considerable sums of money in circulation in their vicinity, Buckingham has not expanded like Western mining "towns" as they are there called, but wears a sleepy, old-time aspect and an air of *insouciance* one would not expect so near mining operations. Its residents, apart from the mining foremen and managers, whose families reside there, are more or less connected with the lumber trade. and have been so brought up in it that no other occupation seems to have charms for them. They are a quiet, harmless folk, mostly of French Canadian stock, who take life easily, do their day's work mechanically, and when night comes on are as happy listening to the old Norman tunes of three hundred years ago drawn out on a violin of antiquity as if there were no to-morrow to provide for.

The rocks of the mountain range that traverses this district are composed of pyroxene, representing the so-called "spotted gabro" of Norway, intermixed with quartzite, orthoclase, mica, gneiss, and crystalline limestone. The phosphate itself varies much, according to locality. It is found in crystals sometimes of large dimensions; in masses, varying from compact to coarse granular; in strata of a lamellar texture, and in a friable form. The latter is very abundant, and is known as "sugar phosphate," often so decomposed as to take the appearance of pure sand, soft enough to be dug out. The colors of the phosphate are very varied, consisting of green of different shades, blue, red, and brown of all shades, yellow, white, and cream colored. Occasionally beautiful crystals are met with, large and perfect at both ends, and enveloped in calc spar, or occasionally a drusy cavity is struck, known in miners' parlance as a "vug," containing sometimes one large or a number of small independent crystals shooting from the sides, or standing erect in the cavity. In one of the mines on the Lievre, crystals of a gigantic size have been met with, some weighing individually as much as one thousand pounds.

Professor Harrington, of the Geological Survey staff, says as a rule the apatite-bearing veins of the Ottawa region are characterized rather by a want of regularity or order in the arrangement of their constituents than by any degree of symmetry. Veins with sharply defined walls, as in metalliferous lodes, are rarely seen, the vein and counter rock merging into each other. Dana says such a blending of a vein with the walls is a natural result when its formation in a fissure takes place at a high temperature during the crystallization of the containing rock. Dr. Sterry Hunt, one of the leading authorities on this continent, who has made Laurentian rocks his study for upward of thirty years, regards many of the apatite veins as fissures or cavities which have been filled by the deposition of materials derived from the adjacent strata. One striking feature developed in this mining is the great irregularity of the deposits; but taking into consideration the extremely disturbed character of the Laurentian rocks, this is not to be wondered at. What may at one time have been layers regular and uniform, subsequent disturbances and upheavals may have folded over and twisted and dislocated till in one place the matter has been compressed into the narrowest of seams, only to swell out further on in an expansion of material giving the appearance of huge pockets apparently isolated, if the connecting vein be not traced or looked for.

The question is frequently and naturally asked, "How has phosphate been formed?" To answer this may require a slight digression from our main subject, but it is at the same time so closely connected with it as not to be out of place here. Dr. Dawson, a prominent geologist, and son of Sir William Dawson, of *Eozoon Canadense* fame, has given perhaps the best explanation on this point. He says there are two sources of supply, viz., the concentrated deposits of phosphatic matter known as the guanos of South America, and the crystalline deposits of Canada, Norway, and Spain. The guanos he divides into nitrogenous and phosphatic, the former being the bird excrement occurring in the exceptionally dry climates of the South American coast, where the organic matter converted by decomposition into ammonia salts remains as part of the mass. In the latter, the phosphatic rain has removed the soluble ammonia salts, but has left the phosphatic material, such as the guanos of the West Indies. The deposits in the south of France, known as Bordeaux phosphates, are of a similar nature, and may be traceable to mussel mud or the accumulations in shallow tidal estuaries of mollusks and other marine organisms. In the Laurentian rocks of Canada is a great volume of sediments deposited in the earliest ocean of which we have any trace, but which, originally resembling the deposits of later seas, has been so completely altered by volcanic and igneous action that its materials have entered into new combinations and have become entirely crystalline, resembling in their present condition the original deposits as little as do the crude ingredients of glass the finished product. There is now among our geologists little doubt of the original sedimentary origin of these Laurentian rocks, mussel muds, sand, and coprolite layers being changed to wholly crystalline rocks. To substantiate this theory, Dr. Dawson adduces the fact that limestones thus acted upon would assume a crystalline character as marble, beds of a peaty or coal nature would pass into crystalline carbon or graphite (plumbago), and phosphate layers would appear as crystalline calcic phosphate, or apatite. All these substances are found in close contiguity in the Ottawa district, being thus evidences pointing directly to the correctness of the theory.

In the early days of mining in the Ottawa district, small operators were beset with countless difficulties, which materially retarded the development of this industry, but it has within the last few years been stimulated by the investment of foreign capital and the organization of powerful companies composed of men of practical business ability, intelligence, and means. The first methods of mining employed here were of the rudest and most elementary kind. The only hoisting and pumping machinery was a tub on the end of a rope, swung over the pit by a derrick worked with one horse. The pits being as wide at the mouth as below, if not wider, were well calculated to collect all the surface water and melting snow, and often when the water had accumulated to any extent the pit was abandoned, and another opened in close proximity, to have in its turn the same fate as the other, so rich and abundant was the mineral on the surface. Now, however, steam power and improved machinery, steam drills and hoists, have taken the place of the horse, the pick, and the bucket, tramways are used to facilitate transport, and a thoroughly business management of the mines generally has placed the work on a sound and permanent basis.

Mention was made above of two rivers in this region, the Gatineau and the Lievre. The former, though picturesque in the extreme from its broken waters and bowlder-obstructed shallows—a favorite resort for the artist and naturalist—we may dismiss as useless in connection with our subject; its very picturesqueness making it unnavigable. The Lievre, on the contrary, although a series of falls and rapids extend for some distance upward from its mouth, is navigable from the village of Buckingham for some twenty miles. At the village there are two very fine falls, one of which was years ago monopolized for driving saw mills, the erection of which really created the village; and the stretch of water above this point being slow, sluggish, and deep, is utilized to the utmost for floating down the mineral from the mines and for conveying supplies and machinery to them. Several small steamboats ply between Buckingham village and the High Falls, some twenty miles up stream, while the ore is towed down in flat bottomed barges or "scows," as these boats are here called, to a landing place north of the village, where the branch line of railway before mentioned terminates. This affords ready and convenient transshipment into cars from which no further change is necessary till they run on the wharf in Montreal, alongside the ocean vessel waiting for its freight. Most of the large mines are situated near or contiguous to the Lievre, along the banks of which bins are here and there built to which the ore is drawn in winter, and where it accumulates till spring loosens the icy fetters of the river. The greater part of the teaming is done during the winter, the snow roads being best adapted for hauling large and heavy loads on runners, and snow may generally be calculated on from early in December to the end of March. The surface of the river during that period affords an easy road for the sleigh and the cutter, and these conveyances lend as much animation to the scene as the steamboats of the summer.

The High Falls, just alluded to, are formed by a mountain spur crossing the river, over which it takes a dizzy leap of eighty feet perpendicularly. These falls resemble those of Montmorency, near Quebec, leaping, as they do, with one bound into a boiling and seething abyss, which, forming on one side a crescent-shaped bay all flecked with foam, narrows toward the head of the long rapids below, girt on either side by a theater of hills and rocks, weird, wild, and picturesque. No mining of any extent is as yet carried on above the falls, although there is abundant show of phosphate, but several small openings have been made, precursors of more extensive operations at the proper time. Mining proper has, up to this time, been confined to localities trending on the lower stretch of navigable water, the following mines being among the most productive.

The Emerald Mine, distant some nine miles from Buckingham village, is the oldest of all, and it was on the site of this mine that the existence of phosphate here was first discovered. For several years thereafter only small quantities were taken out at a time, pending the results of the market value and demand for the new material, but when that was once established, work was commenced in earnest, and is now carried on there on thoroughly scientific principles. The ore it yields is of a very high grade, and of a pale sea-green hue. This mine has changed hands several times, each succeeding purchaser paying enhanced prices till the last sale to the Ottawa Phosphate Company, for one hundred thousand dollars, cleared the seller nearly half that sum, and it is doubtful if five times that amount would tempt the present company to part with it. The property covers one hundred acres, but the mining is confined to only a small portion of the lot. A drift penetrates the side of the mountain to the main shaft, and galleries are run in every direction, under the supervision of a practical Cornish mining captain. The veins of phosphate in this mine range from 12 to 30 feet in thickness. The appearance it presents from the river is very striking.

The huge drift or tunnel surmounts a plateau, midway between the mine and the water, on which is a cluster of cottages and buildings presenting the appearance of a small village, while the bright green phosphate sparkling in the sun, and the clumps of waste rock lying in heaps around, give evidence of the large force of miners underground.

The Little Rapids Mine, two or three miles further up the river, lies on another mountain, and is the property of Mr. William Allan, of Ottawa, who is sparing no expense in developing the rich veins which have been followed here for several hundred feet by deep shafts, from which drifting is carried on at different levels, and by a large open pit assuming the dimensions of a quarry, in a cross cut from which the miners are now working in solid ore forming the roof, floor, and sides. The return of shipments from this mine gave in one case in London 85·79 and in another 85·18 per cent. tribasic phosphate of lime, probably the highest analyses yet reached in cargo lots from Canada.

The North Star Mine, a short distance from the preceding, belongs to an American company, and is yielding handsome returns. Some months ago the owners, desirous of testing the depth of the deposits on their property, instructed their superintendent to sink a test shaft. A spot where the vein on the surface was not more than three or four inches wide was selected, and the shaft was proceeded with till, at a depth of 30 feet, the vein increased to a width of two feet, ranging after that from one to four feet till a depth of eighty feet was attained. Here the phosphate almost disappeared, but, nothing daunted, the miners went on till, at a depth of 120 feet, a vein one foot wide was reached, which gradually kept on increasing. At a depth of 165 feet a body of phosphate was penetrated occupying the whole width of the shaft. Sinking was still continued, and now, at a depth of 266 feet, the entire floor and sides are pure phosphate, and a drift run for some distance at the 200 foot level shows solid ore. The prospects thus given by actual test insure a heavy output for some months to come.

The High Rock Mine lies on the west side of the Lievre, some eighteen miles up the river from the village, and has always been the heaviest producer of all the mines. It belongs to the Phosphate of Lime Company, of London, under the management of Mr. Pickford, of Fenchurch Street, and the property covers twelve hundred acres.

The force of men employed varies from 180 to 220. The profits of the last four years have been sufficient to cover all the outlay and to admit of a dividend of from twenty-five to thirty per cent. on the capital stock. Improved machinery of every kind and the most skilled methods of mining are in use here, steam being exclusively used for drilling and hoisting. Some thirty openings exist on this property, in each of which mineral is abundant. Every attention is paid to the comfort of the miners, both as regards eating and in sleeping accommodation, and a reading room well sup-

plied with books, papers, and periodicals is open for the employes in their off time. The view of the surrounding country from the lookout at High Rock is magnificent. In all directions the Laurentian Hills rise one above another in the distance, while at the foot of the mountain itself is a flat savanna or "beaver meadow" of several acres in extent, fringed with a growth of trees. These beaver meadows are so called from the supposition entertained that they mark the site of a lake originally formed by beavers damming a stream, but which, with the disappearance of these animals and gradual destruction of their dam, has become a rich meadow. To the west of this a valley is seen dotted over with settlers' houses, whose residents find a ready market at the mines for all their produce.

The Union Mines, about one mile further north, and on the same side of the river, belong to an American company, under the management of Mr. Williams, president of the New York Mutual News Association. The property covers two thousand acres, and where only, four years ago, rocks and unbroken forest prevailed, there are now substantial offices, workmen's dwellings, storerooms, tramways, and good roads. Mining has here been reduced to a minimum by steam power. A small lake nestles at the foot of the mountain on which the chief works are carried on, and a ravine, along the edge of which a tramway runs, receives all the waste rock. The escarpment forming the face of this ravine shows the course of the phosphate veins as if pictured on a wall, and affords a splendid opportunity to the mineralogist to pursue his investigations. The original capital of this company, of one hundred thousand dollars, was nearly all expended in plant, road making, and shaft sinking, yet at the close of one year's operations a dividend of thirty per cent. was earned and divided among the stockholders.

The Glasgow Canadian Phosphate Company, a wealthy Scotch organization, has, within the past year, commenced operations in a range of hills on the east side of the Lievre, and has struck very rich veins. Their buildings and mining plant are of the best, and neither pains nor expense are being spared in developing their property, covering six hundred acres. Owning, as they do, mineral land in different localities, and not altogether in one spot, this company bids fair to rank among the largest operators in the Ottawa region.

The above are the largest and best developed phosphate mines of this district, but numerous other smaller mines are being steadily worked, and are contributing to the general yield of ore. Some idea of the magnitude this industry is assuming may be gathered from the following figures, taken from the trade and navigation returns, showing the exports of phosphate from Canada during the past five fiscal years. In 1880, seven thousand nine hundred and seventy-four tons; in 1881, fifteen thousand six hundred and one tons; in 1882, seventeen thousand one hundred and eighty-one tons; in 1883, fourteen thousand four hundred and seventy-eight tons; in 1884, twenty-one thousand four hundred and seventy-one tons; while the total shipments of the calendar year 1885 amount to twenty-four thousand two hundred and ninety tons.

Professor Boyd Dawkins, the British geologist, who was out here with the British Association for the Advancement of Science, visited the phosphate district, and on his return home stated in a paper read by him at Manchester, on "Canadian apatite," that "it would become one of the most profitable resources of this country," and Professor Hoffman, the analyst of the geological survey staff, says that from its usually high percentage of phosphate of lime, "Canadian apatite may be regarded as a most eligible material for the manufacture of superphosphate."

In addition to the yield of pure phosphate in large masses, it occasionally happens that large quantities of it are mixed with mica, pyroxene, and other foreign substances, and if shipped in that state, the value of the whole cargo would be materially deteriorated. To get rid of this extraneous matter a process known as "cobbing" is resorted to, which consists of the separation by hammers of the ore from its matrix, an easy operation, owing to the more friable condition and softness of the phosphate as compared with the intrusive materials. This is done in a hut or cobbing-house, on solid tables or stands. On one side of the building are tramcars or wagons, into which the refuse is thrown as broken off, while the phosphate thus cleaned is thrown into another receptacle on the other side. Boys and old men are employed at this work, which no machinery has yet been found adapted to perform. In spite of every care used, large quantities of phosphate are thrown aside at present which, with an improved system, may yet prove of value, much in the same way as the early gold workings of California and Australia yielded rich returns when their tailings were again worked over.

The drawback to the conversion of the crude material into superphosphate at or in the vicinity of the mines, to obviate shipping the raw material, is caused by the absence of pyrites in the apatite district in quantity sufficient to warrant the erection of works for the manufacture of sulphuric acid, by means of which the mineral is converted into a fertilizer. The nearest deposits of pyrites in any abundance are those worked in the district southeast of Montreal, known as the Eastern Townships, some 200 miles distant from the apatite region. The cost of transport thence would be more than it now costs to ship the crude phosphate to Europe. If pyrites at some future day should be discovered near the phosphate mines, where it has already been found in small quantities, there would be little difficulty in manufacturing fertilizers on the spot, and a very large and new industry would spring up. The water power of the Gatineau and Ottawa rivers is unsurpassed, and would afford every facility for grinding the ore prior to treating it chemically with the acid.

A curious feature in the phosphate trade is the fact that, although a large amount of American capital is invested in Canadian mines, almost the whole of their product is shipped to Great Britain and the Continent, a trifling quantity only finding its way to the United States. Considerable crude phosphate and a large amount of superphosphate is imported into the United States from Great Britain, and there is every reason to believe that both these articles are of Canadian product, reshipped. Mr. Torrance, a phosphate expert, gives as his idea of the reason for this anomaly that as American dealers were in the habit of importing from Britain long before Canadian deposits were worked, no effort has since been made to direct the trade from Canada into fresh channels, a trade which was commenced with the English market by men more familiar with that than with the American. Dr. Sterry Hunt, in the paper read by him last summer, entitled "Studies of the Apatite Deposits of Canada," before the American Institute of Mining Engineers, at Halifax, remarked that in the near future a large market will be found for this material in the United States. The growing demand for high fertilizers on this continent, and the fact that the apatite of Canada may be shipped to the valleys of the Ohio and Mississippi at much cheaper rates than the phosphate rock of South Carolina, give a great importance to these Canadian mines.

The large increase in the annual output of the more important mines is evidence that Canadian phosphate is coming more and more into demand as the mineral becomes better known. Every pound of phosphate that can be mined here is in demand for shipment at a price that shows a margin of profit of from seventy-five to 100 per cent. on the cost of production. The high grade of this phosphate has brought it into favor in Belgium, Denmark, France, and Germany, in which countries there is an increasing consumption consequent on the widespread cultivation of the sugar beet, for which superphosphate is found to be an admirable fertilizer, and in England there is a wide market for it. The objections which Canadian phosphate encountered at first have been got over, and the difficulties met with in introducing material from a new source have been overcome. A low grade of Belgian phosphate is found to combine well with Canadian under chemical treatment. There is a question as to the continuance of the supply of Spanish phosphate, which, with the high cost of the Norwegian article, favors an increased demand for the supply from Canada.

Besides the phosphate bearing district of the Province of Quebec, described above, there is also a phosphate producing region in the Province of Ontario, occupying that portion of country lying back from Kingston and Belleville, which extends in a belt through the townships of Burgess, Crosby, Bedford, Storrington, and Loughborough, in the County of Hastings. A large number of surface openings exist in this belt, some of which are worked with fair returns, but no deep mining has been carried on. While the productiveness of and easy access to the Lievre mines have caused the neglect of the earlier discovered deposits of the Hastings district, there are among these some which will probably, when properly developed, be found not inferior to those of the Lievre.

The same attention has not been given to this district, and prospecting has not been carried out to nearly the same extent as in the Laurentian Hills. So far as known at present, the grade of phosphate is not as high as that of the Quebec mineral, and the amount shipped from Kingston is comparatively small. A description of this section and its surrounding metalliferous rocks, with their mines and industries, must be reserved for a future article.

CREASE DIRT: WHAT IT IS.

CREASE dirt exists in all kinds of wheat naturally, that is, there is a certain proportion of crease dirt that belongs to every grain just as much as the germ or bran does, and this natural crease dirt can be augmented by other kinds of artificial dirt, either by careless handling or poor smutting or scouring. There are many smutters and scourers that break the wheat and smut balls, without being entirely able to liberate the dirt as it is loosened, and this dirt finds its way into the crease and adds to the natural dirt which is in every variety of grain. Botanists tell us of the male and female protoplasms in the fertilization of the wheat berry and of the pollen or sperm cell which incloses the germ of the male. The wheat berry is divided into two conjunct halves by the median line or crease, and to each half there is a style on the summit. The hilum end is covered by two scales which are the anthers or male organs, and each scale has a double pouch containing the pollen. In the process of hybridization the pollen from one plant is shaken over the female organs, the stigmas, on the styles of another.

There is a feathery membrane in the crease which dries up as the grain ripens, and consists of a vital impurity. In this part of the crease will be found the old pollen cells. The anthers of the plant, where the pollen cells originate, shed them in large numbers on the stigma or feathers which is attached to the ovary during the short time that is required for pollention. Only one of these many cells, is necessary for the act of fertilizing the embryo-cell; the rest remain in the crease of the berry entangled among a mass of vegetable fuzz. These pollen cells change their color as the grain ripens. They are first of a white milky color; they then become brown, and finally black with age, but their vitality is not destroyed. They are simply dormant, and moisture or warmth stirs up their nature to such an extent that they exert the same destructive action on gluten as the germ, or the cerealine. This is the natural crease dirt of the berry, and should be removed by all means before it reaches the flour to not only discolor it, but to add its baneful influence, not only on the color, but quality of the flour as well. These are the scientific reasons for the removal of crease dirt. If any doubt of its existence, they have only to split a grain with a penknife and place the lobes under a magnifying glass, when there will be found a deposit of bluish black dirt at the bottom or core of the crease. There are some who say that this can be brushed out; but as the natural dirt is in the core at the bottom of the crease, shown in annexed cut, magnified eighteen

diameters, it is impossible for any bristle, no matter how fine, to enter it, and it may even be doubted if a strong steel wire of the same thickness of a bristle, or even finer, could be forced into this core at the crease while being held firmly in the hand. It is not possible therefore to get them into it when not held at all, but kept flying around between the bristles of the brush, which only slip over it and do not nor cannot enter it. This must be apparent to any one that gives the subject the slightest thought or attention. It is therefore important for the manufacturer of pure and durable flour that this crease dirt, and also the germ, should be removed before any flour is made; and as there is no means of doing this without first splitting the grains in two even halves longitudinally at the crease, it then follows that the machine that does this in the most perfect manner without making flour is the best.

The next thing in order after this is to remove this dirt; as it is pasted up against the sides of the grain, and is in a sense as hard to be removed as the dirt attached to the outer bran, it must therefore undergo a process of scouring after being split. This must be gentle, by means of a brush with long bristles, so that no flour will be made, but at the same time it must be thorough, so that no dirt will be allowed to remain lodged against the side of the berry, and as it is loosened it should be removed at once.

Wheat treated in this way will be in the most perfect condition for flouring by any system of milling, whether rolls or burs, and the value of the product will be increased, not only by its color, but by its being in a better condition for baking. It must not, however, be thought that splitting the grain and depending on chance for the removal of dirt are sufficient. The split grains must undergo a process of cleaning by brushes and aspirators before this dirt lets go its hold.—*The Miller.*

THE EARTH AND THE COMETS.

A RECENT Lowell Institute lecture by Professor C. A. Young related mostly to comets. He took up in beginning a topic which had been omitted in the preceding lecture for want of time, the uniformity of the earth's rotation. It is highly important, he said, to know that this motion is uniform, for it is the unit of time from which all other measures of time are derived. It is certain that this motion has not varied in 2,000 years so much as 0·01 of a second, though it is impossible to say that in the term named it has not varied 0·001 of a second. The action of the ocean tides has the effect of retarding the earth's motion slightly, but this is compensated for in the fact that the earth is growing older and contracts somewhat. So far as it diminishes in size its tendency is to move more swiftly. There are geological causes in operation, but these practically balance each other. An accumulation of the earth's mass near the equator would have the effect of making the earth rotate more slowly. This effect is produced by action of great rivers like the Mississippi, which take up debris in Montana and deposit it in the Gulf of Mexico. But the Mackenzie river and other rivers in Siberia are working the reverse way, and carrying debris toward the pole. An accumulation of ice at the poles would also tend to offset the loss of speed through tidal action.

As to the comets, he said that they are the most impressive and at the same time the least significant of the heavenly bodies. The least of the known asteroids has probably more influence upon the solar system than any comet. Aristotle's idea about comets was that they were exhalations of foul air from the earth's surface, which having ascended into space could not get beyond the moon, and eventually, when the mass became large enough, it took fire and was consumed. He thought they might produce unwholesome conditions on the earth, and while they raged calamities might ensue, especially to the great men of the earth, made of finer clay than the ordinary men. The astrologers attributed the disasters attendant upon the coming of comets to purely astrological causes. The idea was accepted by the ancients that they were the souls of great men on their way to heaven. The comet which appeared in 43 B. C. was supposed to be the soul of Julius Cæsar. Scientific investigation has shown that the theory of malignant influence will not stand the test, and statistics prove that as many catastrophes occur in periods when there is no comet as in other periods when they have been present. The theorists of maleficent action have in some periods been hard pushed to find supporting facts. In one instance it was adduced that the appearance of a comet was attended by great flights of pigeons in Pennsylvania, which roosted among the orchards and broke down the branches of many valuable fruit trees. In case of another comet, it was said that much sickness and mortality prevailed among the eats in Westphalia. There were not wanting in this generation believers that the Civil War in this country was to be accounted for by the coming of the comets of 1858, 1861, and 1862.

There have been 660 comets recorded since the beginning of the Christian era, those antedating the telescope being such only as were visible to the naked eye. From three to six comets are usually discovered each year. They are some of them best known by the names of their discoverers, as Donati's comet or Encke's comet. Science knows them also by numbers and letters as comet No. 1 of 1885 or comet A of 1885; but comet No. 1 and comet A may not be the same. The letter refers to the comet first discovered in a particular year, while the numeral refers to that which was first to go around the sun. The bright or large comets do not appear with equal frequency in periods of centuries. In the sixteenth century there were 23 such; in the seventeenth, 12; in the eighteenth, 6; in the nineteenth, thus far, 20; so that this century has a fair prospect of rivaling the sixteenth century. The orbits of many of the comets are in the form of a hyperbola, showing that they never will return. There are 25 or 30 whose orbits are elliptical, and the returns of which may be predicted, and there are besides 15 to 20 which are probably, but not certainly, elliptical. The planet Jupiter is believed to have been the cause of the most of these elliptical orbits, there being 12 or 14 comets which he may be said to have adopted into his family. They go forth and around the sun from time to time, but on their return keep within Jupiter's attraction, and curve at shorter or longer distances about him in aphelion. Their initial motion would have carried them indefinitely into space had they passed at sufficient distance from this great planet in going forth, but once within his attraction they could not escape, and so continue to move to and fro.

The lecturer thought it to be quite within the probabilities that a comet will one day strike the earth, as several have passed through the earth's orbit. He had no fears on that score, thinking that the effect might

be a magnificent display of shooting stars or the like, and would like to see it. It is known that the earth has on more than one occasion passed through the tail of a comet, but it was not known until after the event, and no effect noticeable was produced in the passage. The nucleus of the largest comets is not more than 0·00001 of the diameter of the earth. If, as some suppose, the nucleus may be a body of iron in a molten state, that diameter would be equivalent to 100 miles, and the stroke might be something serious. The lecturer inclined to the theory that the nucleus is a mass of dust or powder carrying a gas in a burning state. While he would not say that the phenomenon of the tail is an electrical effect, he would say that the appearance corresponds to what might be the effect of an electrical repulsion of particles of attenuated matter by the sun. Many facts were given about particular comets, which were represented in a very realistic manner upon the illuminated screen.

AN AMATEUR ASTRONOMER.

MR. LOUIS GATHMANN is President of the Garden City Mill Furnishing Co., of Chicago. The inventions of Mr. Gathmann in the mill furnishing line have a worldwide reputation, and are known wherever grain is converted into flour.

During his leisure hours his hobby is astronomical; and while many a spare moment is devoted to this fascinating science, business is never neglected. He can be seen early and late at the company's factory, superintending the manufacture of his special machine, watching every opportunity to make improvement and to the carrying out of his experiments for new inventions. Every machine that his company manufactures must be personally examined by him before leaving the shop and receive the stamp of his approval.

The following we clip from the Chicago *Tribune:*

"Among the amateur astronomers of Chicago is Mr. Louis Gathmann, the manufacturer, who has a fine house at the corner of Lincoln and North Park avenues. Mr. Gathmann is forty-three years old, was born in Hanover, Germany, and has lived in Chicago twenty years. Having been prosperous in business, he has the means of gratifying his tastes, however expensive. He has been all his life a star gazer, having been instructed in the rudiments of astronomy and acquired a taste for it in early childhood from his father, who was a school teacher. His only object is his own enjoyment; but he has made arrangements for gratifying his scientific taste that are creditable to the city of his adoption as well as to himself. At the present time he is just putting the finishing touches on a regular observatory, begun several months ago, and erected as an addition to his private residence. This is a five story brick building, eighty-five feet high, octagonal in shape, and built on a very solid foundation, with a view of preventing vibration. It is surmounted by a sheet iron dome, with machinery for revolving it, and with a sectional window and shutter.

"Fifteen feet from the summit it is encircled by a spacious iron balcony, from which one may get a most enchanting view of the city and the lake, as well as of the heavens. The cost of the structure, exclusive of the instrument, was $8,000. The whole of Mr. Gathmann's house bears the marks of his devotion to this subject. The hall, the parlor, and especially the rooms and walls of the observatory are filled with globes, maps and illustrations of every phase of astronomical observation. The telescope, which he has had for some years mounted in the small square tower of his residence, was made by Schroeder, of London. It cost $3,700, and has an object glass seven and a half inches in diameter. It is an instrument of high finish, with much of the pharaphernalia of the largest telescopes, including a 'finder.' The machinery for adjusting it is unique, and is entirely of Mr. Gathmann's own invention and manufacture.

"The observatory was purposely adapted to a larger instrument, as it is his purpose to secure a larger one before a great while. He has in the instrument-room the small telescope, three feet long, with which he began his observations, and which has been constantly supplanted with larger ones, until the present instrument was obtained. But this has whetted his appetite for something better, and Clark, of Boston, is likely to receive an order before long for a telescope for Mr. Gathmann with an object-glass at least twelve inches in diameter.

"Mr. Gathmann is a subscriber to all the periodical astronomical literature of Germany, and amuses himself with confirming by his own observation the observations of all the great astronomers of Europe. He is in his observatory every evening when the sky is clear, and sometimes works until 2 o'clock in the morning. He says he is utterly at a loss to know why people of means throw away their wealth in mere animal enjoyment, while at a smaller expense they might enjoy the sublime and ennobling emotions of the astronomer."

CANDELABRA CACTUS AND THE CALIFORNIA WOODPECKER.

To the Editor of the Scientific American:

I note an article in the SCIENTIFIC AMERICAN of Dec. 12, 1885, on the "Candelabra Cactus and the California Woodpecker," by C. F. Holder, which was very interesting to me, from my knowledge of the array of facts that fortifies the spirit of the article.

The paragraph that most interested me was the description of the habits of the woodpeckers, which is quite in harmony with my own experience of four years, under the sound of their busy hammering and shrill screaches, in the precincts of Rough and Ready, Penn Valley, the Old Zinc House, and the hydraulic mining town of Timbuctoo, during the years '58 to '62. I was lumbering for two years, not far from the places above mentioned, and felled many pine trees, of three different kinds, the "Digger Indian," the "Pitch," and the "Sugar" pines, all of which contained more or less nuts and acorns, stowed into pecked holes in the bark, and I had quite as favorable an opportunity to observe the habits of the California woodpecker, as Mr. Paul Oliver, of Perryville, Ohio, says he had, in your issue of Feb. 13, 1886, where he claims that only for a chance shot made by him with his rifle, "the persistence of his (the woodpecker's) character would otherwise never have been known."

He doubtless refers to that certain woodpecker which, from description given, I claim was an inexperienced workman of his kind, from three different standpoints: 1st. That it requires more labor with bill power to peck a hole to admit the square end of an acorn than the pointed end. 2d. That the square end protruding, or even with the surface, renders the meat therein of easier access for a dinner on the "whole shell." 3d. That he displayed want of precaution in bruising away the upper portion of his bill "to the raw flesh." Of their industry, there are no grounds for difference of opinion, but as to their perfect organ of size—and the end of the acorn they do insert into bark of trees and rotten wood—a question might arise.

I have felled pine trees where acorns have easily dropped out of newly made holes in the bark, while others of longer setting remained solid in the cavity, by the contraction of the bark, caused by the nature and growth of the tree, to heal a breach made in its armor. After the lapse of a year, in the case of growing trees, the contraction of the incision renders the acorn immovable, and it can only be got out whole by cutting away the tough bark.

It was about thirty-six years ago that Mr. Oliver makes mention of his experience in California, and I am therefore impressed, considering the lapse of time, that his memory is somewhat at fault. His aim with the rifle was probably at the eye of the red-headed woodpecker, and missing it, the bullet carried away the upper portion of the bill "to the raw flesh;" hence the bird's dissolution, and the new discovery claimed to have been made.

C. H. CHASE.

Bridgewater, N. S., February, 1886.

A PROSPECT FOR RAILWAYS IN CHINA.

THE United States Minister at Pekin says: The most prominent man in China to-day is Li Hung Chang, who is Grand Secretary of the Empire, Viceroy of the province, and one of the heads of the Admiralty Board.

There seems every reason to believe that he will succeed in his plan of constructing railroads. A complete working model railroad was recently procured from the United States. It consisted of one hundred feet of main track and sidings, with switches and turntable, a passenger locomotive and tender, mail and luggage cars, passenger cars, Pullman parlor and sleeping cars, different kinds of freight cars, a full section of seats and berths in sleeping car, etc. The cars were five feet long, and all other parts of the model were in equal proportion, and care had been taken to make the model throughout an exact representation in miniature of road, locomotive, cars, etc., in actual use in the United States, complete in the smallest detail. The motive power was clockwork. This model was exhibited to the Viceroy, Li Hung Chang, in his yamen at Tien-Tsin, in September last, and he expressed himself much pleased with it, and said he would exhibit it in Pekin when he went there in October. On October 16 the model, which had been conveyed to Pekin, was again exhibited before the Viceroy by his order, and on the following day the Viceroy presented it to Prince Chiûm, the Emperor's father. Several native mechanics who were able to work the model went with it to the Prince's palace, and worked it successfully in the pleasure-grounds of the palace. The prince was highly pleased, and thanked the Viceroy heartily. He also gave presents to the mechanics, and had them instruct his own attendants in the working of the model. Two days later the Prince sent the model to the Imperial palace, where it was exhibited to the Emperor and Empress Dowager, and worked successfully. Their majesties were much interested and amused, and spent some time in a minute examination of the model. It was the first and most complete representation they had ever seen of the much-talked-of railroad, and it enabled them and the Prince to realize many of the benefits that this modern institution would confer on China It is understood that the event materially assisted the Viceroy in his advocacy of railroads for China, and their majesties lent a willing ear to all he had to say in favor of railroads, and agreed to allow him to prepare for their introduction into the country.

A NEW THIEF-TRAP.

A NEW LONDON man has invented a thief-trap, which the *Providence Journal* describes as follows: The trap consists of a hole some ten feet deep, dug in his floor, in the shape of the frustum of a square pyramid, so that once the thief is in he cannot shin out. The hole is covered by a door hung on a central pivotal bar, and weighted in such a manner that when the thief, who has stepped on it, has dropped in, it is brought to its normal position, and the jar works a spring lock to secure the prize. We hope, adds the editor, to see this thing pushed to as near perfection as possible, and we think that the New London man is on the right track. Burglar alarms have never satisfied us as a solution of the difficulty; they only serve to wake a household up to the realization that a burglar is among it, when without the alarm the family might sleep undisturbed and without fear, while the burglar came and went his way. For our part, we would feel much more comfortable if we knew nothing about the burglar in our house than if we did. Besides, the burglar alarm does not catch the burglar—and what is imperatively demanded is something that will catch the burglar. The New London man's trap seems to have the fault of catching everything and everybody that comes along, including a sheriff's keeper, but future experiment can remedy this. We should not be surprised if at no distant day the thief-trap in all its perfectness of action will become one of the architectural features of every house together with other modern conveniences.

The trap in its first principles is now before the public, and improvement will lie in the direction of making its action absolutely certain; of securing noislessness of movement, so that the thief may be caught without unnecessarily alarming the family; of securing ornateness in an architectural sense, so that it may be adapted to the most elegant residences; and of devising some unobtrusive but effective method to preclude the possibility of entrapping the man who comes home from the lodge, tra-la, instead of the thief.

A NEW GOLD MINE IN ASIA.

A RECENT letter in the *Journal des Debats* gives an interesting description of the new California, as the gold mines discovered in the valley of the Djolgute River are called. This valley is upon the Chinese bank of the Amoor, directly opposite the Russian colony of Ignachino. Gold was first discovered in May, 1884, and soon attracted many adventurers, most of them being Russian deserters, escaped convicts from Siberia. The number of these in January last year was 9,000, which has since been very materially increased; also about 6,000 Chinese and some 150 of other nationalities. The gold finders are divided into 722 small groups of workmen, who are absolutely equal. These elect 12 elders, who do not work themselves, but receive about $150 per month salary, and superintend the diggings. The colony does not meet with any interference from the Chinese authorities, the laws of which are very simple and severe, the penalty of death being inflicted for cheating at play, for adulteration of gold dust, or for theft, while flogging is inflicted for drunkenness during hours of labor or bringing females into the colony. The gold fields are 25 miles in length and 3 broad, and are said to be very rich, 7 pounds of gold being obtained from 32 cwt. of gravel, even with the primitive methods of washing in vogue.

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